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PRODUCTION FABRICATION TREATMENT APPLICATION

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HIGHLIGHTS

Written by the Abstract Section Editors and the Editorial Staff

DO YOU want to know what metallurgical engineers are saying, the world over? Look in the Current Metallurgical Abstracts. Here are some of the points covered by authors whose articles are abstracted in this issue.

Purifying Ores by Magnetic Repulsion

Repulsion of magnetic material is the process used by C. W. Davis and R. S. Dean (page MA 177 R 4) to purify ores. Unusually clean concentrates are obtained.—J. A.

Oxygen

Körber (page MA 180 R 7) indicates five different relations between oxygen in liquid steel, temperature, and slag and metal composition. When they are boiled down the oxygen problem begins to have some real light thrown upon it.—C. H. H.

Air-Conditioning in Heat Treating

Not only is the atmosphere of the home, office, and factory being studied, but the atmospheres in heat treating furnaces is getting much attention, as indicated by "Control of Scale Formation in Heating Steel" by Bechtel (page MA 184 L 6), "Clean Annealing at Motor Wheel Corporation" by Seger (page MA 184 R 10) and "Continuous Controlled-Atmosphere Furnace Used to Harden Automobile Valve and Clutch Springs" by Prentiss (page MA 185 L 6).—O. E. H.

More Speed in Malleableizing

It has always seemed to some that six days is a long time to heat treat anything. Olson (page MA 184 R 9) says the fundamental principles for speeding up this process are known and that it can be done, but he suggests that the composition of the casting is important. Try-Chalons (page MA 186 L 8) also has something to say on this subject.—O. E. H.

Better Late Than Never

The large tonnage of steel rails which has been used in the "as-rolled" condition seems out of line with the increased use of selected heat treatments in other industries where service performance and safety are important factors. Brunner (page MA 185 L 2) discusses Normalizing Process Perfected for Rails. There is no pleasure in contemplating a wrecked train due to a transverse fissure, shatter cracks, fatigue, coarse grain, or low impact resistance at sub-zero temperatures, and if normalizing eliminates these hazards and produces a rail of better wear resistance, it should be popular. Other heat treatments are also being used to improve rails.—O. E. H.

Age-Hardening vs. Temper-Hardening Alloys

About a quarter of a century ago it was observed by Wilm in Germany that certain aluminum alloys after quenching from temperatures of about 500 deg. C. showed an increase in hardness with time at room temperature. This was called "age-hardening." As this phenomenon has been noted in other alloys, some of which had to be heated to increase the hardness, the use of the term has grown, although "precipitation hardening" and "accelerated aging" have been used. Cook (page MA 185 L 8) suggests a distinction between hardening at room temperature and at elevated temperatures and proposes for the latter "temper-hardening."—O. E. H.

How Much Insulation?

Humphrey (page MA 189 L 2) has worked out a simple method for determining the proper thickness of insulation for industrial furnaces under different conditions.—M. H. M.

Blast Furnaces are Larger

Further increase in size of blast furnaces and other changes in design and operation have resulted from the necessity for cheaper iron, according to Harlan (page MA 189 L 6).—M. H. M.

Accurate Control of High Speed Spot Welding

The necessity of control of current, time and pressure for the welding of austenitic steels for the production of desirable metallurgical and physical characteristics is revealed by Mr. Spraragen (page MA 192 L 10). The value of such control as well as the correct diameter of electrodes make possible the correct welding of stainless steel and show the value in the construction of passenger cars by considerable saving in weight.—C. A. McC.

What is the Best Method for Cleaning Steel Castings?

The use of some method other than acid pickling for cleaning steel castings is recommended by workers at the Naval Research Laboratory (page MA 196 L 5). A casting highly stressed internally as it comes from the mold tends to develop surface cracks as a result of pickling.—H. S. R.

Use of Heating Ring for Stress Relieving of Pipe

The application of a ring collar constructed along the lines of a high frequency induction furnace coil which is portable makes possible the heat treatment of pipe-welds in place, for the purpose of stress relieving and heat treating by taking advantage of the drawing or tempering action which is a partial annealing or quenching of cold worked forgings. This drawing considerably increases the ductility of arc weld deposits (page MA 195 L 2).—C. A. McC.

Cyanide for Plating

The common use of KCN in plating work often dulls our realization of the fact that KCN is one of the most deadly poisons known. Thiocyanogen compounds have been proposed as a substitute and such solutions are claimed to be the equal in every way of the cyanide solution (page MA 196 R 5).—H. S. R.

Fracture Tests in Hot-Worked Steels

The appearance of fractures is correlated with endurance properties, dendritic structure, the shape and composition of inclusions, and the composition of the steel (page MA 198 R 3).—C. S. B.

Carbide Triplets

Iron carbides other than Fe_3C are reported sporadically. The latest is that, under certain conditions, FeC and Fe_2C exist in quenched and tempered steels (page MA 202 L 2).—J. S. M.

Polishing and Etching Stainless Steel

Metallographist Vilella tells all for A. S. T. M. Committee A-10 (page MA 202 L 3).—J. S. M.

Molybdenum High Speed Steel

According to one writer at least, the new molybdenum high speed steel is giving the old 18-4-1 standby a run for its money (page MA 207 L 1).—E. S. D.

Great Stuff, This Vanadium!!

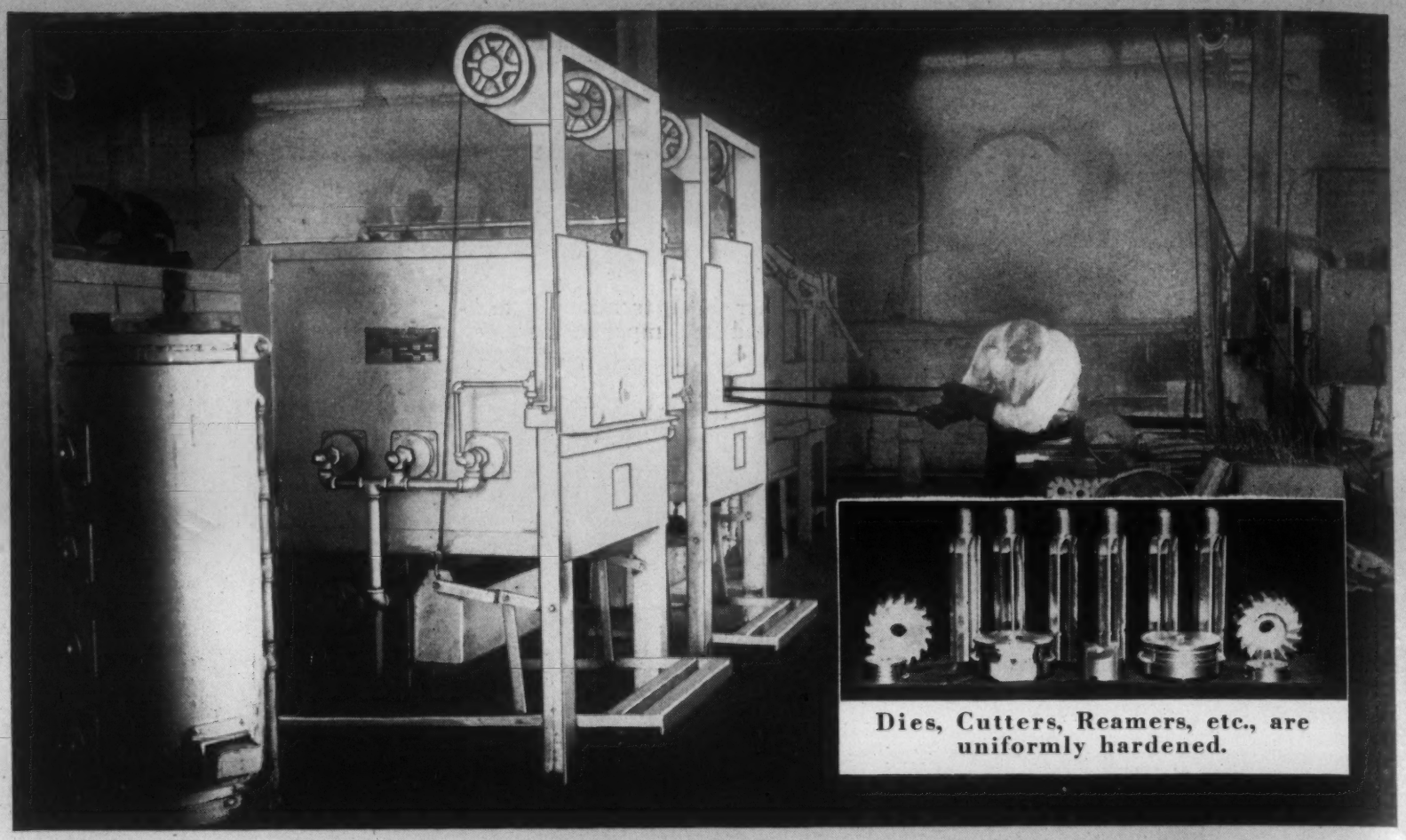
According to Hougardy (page MA 207 L 3) vanadium in steel can do no wrong. Maybe he is nearly right,—it does seem to do some nice things to steel.—E. S. D.

Protecting Pipes Cathodically

Cathodic protection of pipe lines has received considerable attention in the last few years and has been found to be quite effective. It is not indicated that the electrical drainage can be intermittent without decreasing the protective effect, thereby considerably decreasing the power cost (page MA 210 L 2).—V. V. K.

Adapts Thin Sheets for Insulating

Thin steel sheets rolled to produce surfaces with low emissivity and high reflectivity are well adapted for insulation; the use of large air spaces is recommended (page MA 212 L 2).—G. L. C.



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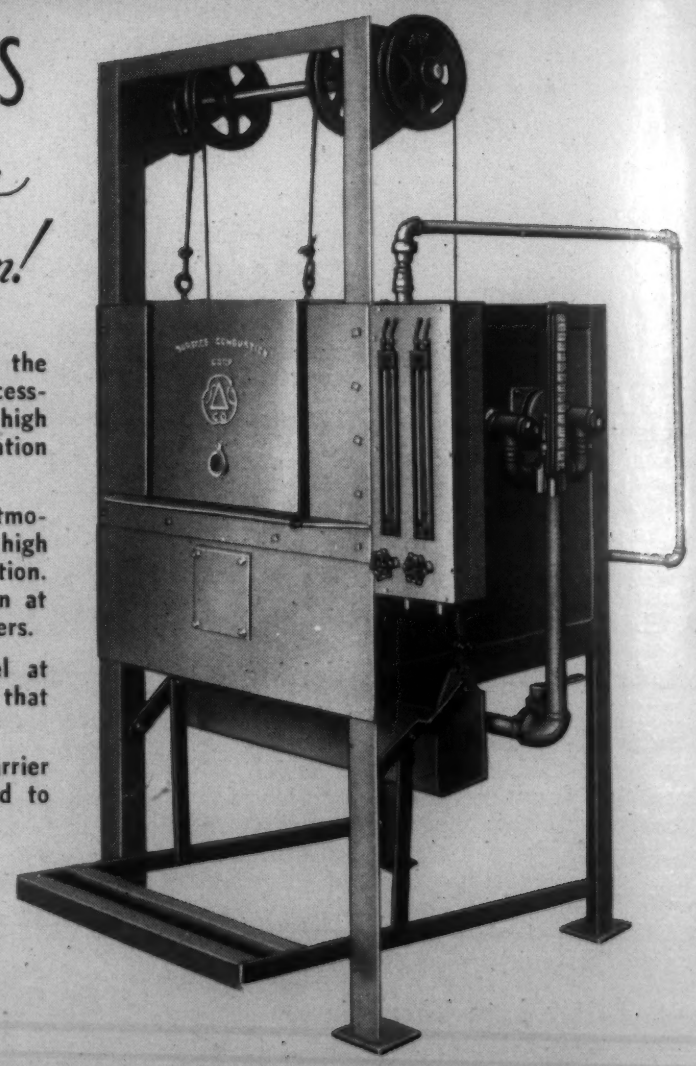

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EDITORIAL COMMENT

Industrial Physics

We had a good deal of satisfaction on reading the account, in the February, 1935, issue of the *Review of Scientific Instruments,* of a conference on Applied Physics. Too many of our universities have been educating high-brow physicists of highly specialized types, the majority of whom have expected to go into teaching and to in turn educate more of the same type. Now there are more such men than there are teaching jobs, and the universities are waking up to the fact that the Malthusian law will hold unless they do something about it.

A group of eminent physicists, several of whom represented large research laboratories which have assimilated a fair proportion of what physicists have gone into industry, others being notable educators in physics, discussed the problem of what sort of physicists industry needs.

Their comments will seem rather brutal to those heads of physics departments who can think of nothing worthy of the effort of a graduate student beside atomic structure and wave mechanics, for the conference expressed itself as believing that emphasis should be placed on classical physics—that is, the principles that underlie engineering, and it also brought out the fact that the physicist needs to know quite a lot of chemistry to go with his physics.

This is healthy. We have seen many applications for employment from physicists who have spent several of the best years of their life in becoming specialists along lines of great abstruseness, and, finding no teaching employment, want to go into research, but have no desire and probably not much ability, to follow other than their own specialties. Some of them practically admit that they would like to be "endowed" so that they might continue their abstruse studies, and seem none too anxious to buckle down to the more prosaic tasks of solving problems of immediate industrial importance. For this attitude their professors and the environment of their graduate study are primarily responsible.

The physicist who does not consider himself above turning to matters of engineering interest, and who has been well grounded in the old-time type of physics, is very often more capable of dealing with a wide variety of difficult engineering topics than is the engineer himself. Few engineers take time for graduate study. Most physicists do graduate work and, if they have not become too narrow specialists in their graduate work, they should have a better grasp of fundamentals than the engineer without post-graduate training.

At the Bureau of Standards one of the job-designations is "Engineer-Physicist." Men who really fill that description would be valuable in any industry, and placing them, under that title, would be far easier than under the title "Physicist."

As Dr. Johnston remarked in the conference, chemists seem to have more sense of the practical than do physicists. We wonder if this isn't largely due to the general feeling of the chemist that his profession aims to be of technical service to mankind, while the physicist tends to feel that it is degradation to deal with practical things and that physics is for the mental enjoyment of the physicist.

The aura that surrounds the student starting to specialize in chemistry is normally quite different from that around the one starting in for physics. The mere labeling of the course he is to take as one leading to the degree of Engineer Physicist would do a lot to create a saner atmosphere. If it becomes fashionable for departments of physics to discard the arrogance that some of them have displayed and really to want to train men who will help industry, a big forward step will have been taken.

This conference may prove the beginning of such a fashion.—H. W. GILLETT.

Structural Damage and Fatigue Failure

As the study of the phenomena of fatigue of metals has become widespread it has become evident that the determination of a fatigue limit or endurance limit does not tell the whole story of fatigue damage. How much is the resistance of a metal to repeated stress lowered by a few cycles of stress well above the endurance limit? Are the fatigue fractures, which so frequently occur in machine parts, the result of millions of working stresses, or of a comparatively few overstresses which weakened the metal? Two experimenters have opened up lines of investigation that should give promise of throwing some light on this problem.

Something over a year ago H. J. French*, of the International Nickel Co., investigated the effects of definite numbers of overstress upon the subsequent fatigue limit under lower stresses, and, for a few metals, added to the ordinary S-N diagram a "damage line,"—a curve to the left of the S-N diagram and merging with it at the endurance limit stress. For values of stress and number of cycles to the right of this "damage line" the fatigue strength of the metal is reduced below the fatigue strength of the virgin metal. For values to the left of the line the fatigue strength is not reduced and may even be increased. If this damage line is far to the left of the S.N diagram, the metal is relatively easily injured by cycles of overstress. If it is close to the S-N diagram, the metal will withstand considerable occasional punishment

(Continued on page 118)

* *Transactions*, American Society for Steel Treating, Vol. 21, Oct. 1933, page 899. An abstract of Mr. French's work appeared in METALS & ALLOYS, Vol. 5, July, 1934, page MA 347 L 5, and a critical abstract by H. W. Gillett in METALS & ALLOYS, Vol. 4, Nov. 1933, page 170.

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Calculation of the Metal Charges for the Foundry Cupola

By H. L. CAMPBELL*

ONE OF THE IMPORTANT factors which contribute to the economical production of iron castings is the exact proportioning of the metals used in the cupola charges. Since the prices of the metals are based directly or indirectly on their chemical compositions, it is imperative that attention be given to the selection and proportioning of these materials. The prices of pig iron are dependent upon the amounts of the elementary constituents in the metal. As the silicon and manganese contents increase, or the sulphur and phosphorus contents decrease, the price advances.

Furthermore, scrap metals are sorted into groups according to the previous uses of the metal parts, which is indirectly a classification based on the compositions of these metals. The prices of the ferroalloys are established on the basis of their important elementary constituents. Since all of the metals used in the cupola charges are purchased on the basis of their chemical compositions, the maximum value of these materials can be obtained only when they are proportioned so as to produce the most favorable composition in the castings.

It is recorded by Thomas D. West that, previous to 1890, practically all foundries in the United States had purchased pig iron on the basis of the appearance of the fractured surfaces of the metal. The iron with the coarsest grains was used for the softest castings, and the close-grained iron was melted for hard castings. The practice of using the fracture-grading method in preparing cupola charges resulted in unreliable properties in the castings. The foundry industry has gradually adopted the more certain method of preparing metal mixtures on the basis of the chemical constituents of the materials used in the metal charges.

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Establishing the Composition of Castings

The first requirement in the calculation of metal charges for the cupola is to establish the limits or range of composition of the castings to be produced. Many combinations of properties can be obtained by the adjustment of the chemical composition of cast iron.

One of the important demands on iron castings today is uniformity in machining qualities. This requirement has resulted from the modern practice of rapid production on repetition jobs in the machine shop. Machine tools are equipped for multiple operations, and if castings of non-uniform hardness are machined, the adjustments of the tools will not remain fixed, and a delay in production and inaccuracies will result. It is not uncommon to find a manufacturing plant paying a premium for castings with uniform machinability. This condition can be obtained by controlling definitely the metal mixtures for the cupola so as to obtain molten metal with a uniform composition.

The Use of Scrap Metals

The metal charges for the cupola are generally composed of pig iron and scrap metals. At every foundry

a certain proportion of the metal poured is returned to the furnace to be remelted in later charges. This material is known as "returned foundry scrap" and "machine shop scrap." It consists of gates and risers from previous heats, as well as castings which have been found to be defective in the cleaning department of the foundry or in the machine shop. The amount of this scrap ordinarily ranges from 25 to 50 per cent of the total weight of the metal poured.

In addition to the returned foundry scrap, it is sometimes desirable to purchase a supply of iron scrap from outside sources. Also, steel scrap is often used in cupola charges. There is a decided advantage in obtaining carefully sorted grades of scrap metals. The composition of the returned foundry scrap will be approximately the same as that of the castings produced. It will be necessary to estimate or actually determine the average analysis of different lots of purchased iron and steel scrap. This information is required when calculating the metal charges for the cupola furnace.

The proportion of scrap metals which can be used in metal mixtures for the cupola will depend upon the chemical compositions of these materials as well as on the changes in composition which take place during melting. Since the sulphur content increases with each melting, the proportion of scrap metal in cupola charges will be limited by the amount of this element which is permitted in the castings. The silicon and manganese which are lost during the melting process must be replaced in subsequent charges. The relative amounts of pig iron, ferroalloys, and scrap metals which can be used successfully in cupola charges will depend primarily upon the chemical compositions of these ingredients.

The selection of the metals for cupola charges will be dependent to some extent on the market prices of these raw materials at the foundry where they are to be used. The relative prices of pig iron and scrap iron may influence the proportions of these metals in the furnace charges.

It is possible to produce iron castings from metal mixtures which contain only pig iron. On the other hand, the metal charges may consist largely of scrap metals with sufficient additions of the ferroalloys to produce the correct average analysis. Since it is difficult to maintain a uniform composition from metal mixtures which contain some of the elements in concentrated form, this practice is not generally preferred. The average practice is to use from 40 to 60 per cent of selected iron scrap in the cupola charges.

In some cases, the addition of steel scrap produces favorable properties in the resulting metal. At many foundries, definite grades of steel scrap such as steel rails, or steel flashings from drop forge plants, are used regularly in the metal mixtures for iron castings. The proportion of steel scrap used in this way may be from 10 to 90 per cent of the weights of the metal charges.

Changes in Composition of Metal Mixtures in the Cupola

In order to obtain castings within a definite range of composition, the metal charges for the cupola must be prepared to compensate for the changes in composition which take place during the melting period. These changes in the amounts of the chemical elements before and after melting will depend to a large extent upon the melting practice. For a given installation and a definite cupola practice, the loss or gain in each of the chemical elements will remain practically constant for all heats.

Cast iron which has been melted in a cupola furnace from mixtures of pig iron and iron scrap will ordinarily contain from 3.40 to 3.50 per cent of carbon. The use of steel scrap in the metal charges will lower the total carbon content of the resulting metal. Although the steel scrap is carburized to some extent during its descent through the cupola, this constituent dilutes the total carbon content of the entire metal mixture. This effect is due to the low carbon content (0.20 to 0.50 per cent) of the steel scrap.

When a metal mixture contains 20 per cent of steel, a total carbon content of about 3.20 per cent is ordinarily obtained. As the proportion of steel scrap in the metal charges is increased, the carbon content of the resulting metal is lowered. When the cupola charges contain mostly steel scrap, the total carbon may be reduced to 2.80 per cent. The final carbon content of cupola metal is influenced to some extent by the height of the crucible, the quality of the coke used, and the rate of air supply.

Some of the silicon in the metal charges is lost by oxidation during the melting of the metal mixtures in the cupola furnace. If this loss expressed as a percentage of the total silicon is equivalent to the percentage of the total loss of metal during melting, the silicon content of the resulting metal will be the same as the average silicon content of the original metal mixture. As a rule, the percentage of the total weight of metal which is not recovered after melting is less than the percentage loss of silicon alone. Therefore, it is usually necessary to supply an excess of silicon in the metal charges over the amount required in the castings.

Since it is difficult to determine the exact loss in silicon alone, it is more convenient to establish the loss factor for silicon and to use this value in finding the average silicon content of metal mixtures for the cupola furnace. This factor is obtained experimentally by subtracting the silicon content in percentage of the resulting metal from the average silicon content of the metal charges, and dividing this difference by the silicon content of the charges from which the metal was produced. The average loss factor for silicon under favorable operating conditions is 10 per cent of the total silicon charged into the cupola. To find the silicon content of a metal mixture, it is only necessary to divide the desired silicon content of the castings by 100 minus the loss factor in percentage.

The amount of manganese in the metal mixtures is also decreased during melting in the cupola. The loss factor for manganese caused by oxidation is normally about 15 per cent of the original manganese content. The oxides of silicon and manganese collect in the cupola slag.

The sulphur content of the metal charges is increased, due to the absorption of sulphur from the fuel used in the cupola. Pig iron usually contains less than 0.05 per cent of sulphur, and scrap iron generally has less than 0.12 per cent. When the coke contains less than 0.75 per cent of sulphur, the metal gains about 0.02 per cent of this element with each melting.

The action of the remelting process as related to phosphorus is mainly that of concentration. The phosphorus and sulphur which are present in the cupola charges are not oxidized during the melting process, but may be removed from the metal to some extent in the cupola slag. An increase of 0.02 per cent of phosphorus in the metal may be assumed in the calculations for cupola charges.

While it is possible to make certain general assump-

tions as to the charges in the proportions of the elementary constituents in the metal charges during melting, these factors can be established experimentally for a given cupola practice. It is only necessary to determine the average chemical composition of the metal mixture before charging, and of the castings produced from this mixture. The loss factor for either silicon or manganese is obtained by dividing the difference between the percentages of the element before and after melting by the percentage of the element in the original metal mixture.

Constituents of Metal Mixtures

The metals are usually procured within the limits of the sulphur and phosphorus requirements of the castings to be produced. When castings with a phosphorus content of less than 0.20 per cent are to be made, the pig iron and scrap metals are selected with an average phosphorus content within the required limits. The same consideration is given to the sulphur content of the materials used. The desired manganese content can be obtained by proportioning the metals used in the charges, or by the addition of manganese in the form of ferroalloys to the molten metal. In most cases only the minimum content of manganese is specified for the castings. The pronounced influence of silicon on the properties of cast iron warrants the practice of using this element as the main factor in calculating the amounts of the different metals to be used in the cupola charges.

After establishing the desired analysis of the castings, the proportion of scrap metals to be used, and the changes in composition due to melting, the materials are selected and apportioned so as to obtain the composition required in the castings. The computations for metal mixtures can be made on the basis of percentage of the elements or on the basis of the weight of the separate chemical elements. The method of combining the elementary constituents on the basis of weight is most direct, and will be used in the problems which follow.

Problems on Metal Mixtures

The solution of definite problems will serve to illustrate the procedure used in calculating the metal charges for the cupola.

Problem I: Find the weights of the materials used in one metal charge for machinery castings having the following composition: Silicon, 1.80 per cent; manganese, minimum 0.65 per cent; sulphur, maximum 0.10 per cent; and phosphorus, maximum 0.50 per cent. Each metal charge will contain 1000 lbs. of pig iron and 1000 lbs. of iron scrap. The average changes in composition of the metal mixture during melting will be assumed. The analyses of the pig iron and scrap iron which are available for the cupola charges are as follows:

	Silicon, per cent	Manganese, per cent	Sulphur, per cent	Phosphorus, per cent
Pig iron—Pile A.....	2.46	0.90	0.045	0.40
Pig iron—Pile B.....	1.35	0.98	0.050	0.34
Iron scrap (auto. cylinders)	2.25	0.70	0.080	0.28

Since the manganese, sulphur, and phosphorus in the materials to be used are within the limits of the requirements of the castings, these elements will be disregarded, and the metal mixture will be calculated on the basis of the silicon content of the metals which are available.

If X represents the pounds of pig iron from Pile

(Courtesy of Warner & Swasey Co., Cleveland)

A, then (1000 minus X) will represent the pounds of pig iron from Pile B for each metal charge. Since the metal in Pile A contains 2.46 per cent of silicon, the weight in pounds of silicon from this source is equal to X times 0.0246. Since the metal in Pile B contains 1.35 per cent of silicon, the weight in pounds of silicon from this source is equal to (1000 minus X) times 0.0134. Since the iron scrap contains an average of 2.25 per cent of silicon, the weight in pounds of silicon from this source is equal to 1000 times 0.0225. Therefore, the total weight in pounds of silicon in one metal charge equals:

(X times 0.0246) plus [(1000 minus X) times 0.0135] plus (1000 times 0.0225).

It is assumed in this problem that the loss factor for silicon is 10 per cent of the total silicon in each metal charge. This factor was obtained experimentally by subtracting the silicon content of the resulting metal from the silicon content of the metal mixture, and dividing by the average silicon content of the metals charged into the cupola. Therefore, the silicon content of the resulting metal will represent 90 per cent of the silicon in each, original metal charge. The total weight in pounds of silicon in one metal charge can be found by dividing 0.0180 which is the silicon content of the castings, by 0.90, and multiplying by 2000, the weight of one metal charge.

Two expressions have now been obtained for the total silicon content of one metal charge. These values can be set forth in an equation; and by solving for X, the weight of pig iron from Pile A can be readily found:

(X times 0.0246) plus [(1000 minus X) times 0.0135] plus (1000 times 0.0225) = (0.0180 divided by 0.90) times 2000

or

$$0.0246\ X \text{ plus } 13.5 \text{ minus } 0.0135\ X \text{ plus } 22.5 = \frac{0.0180}{0.90} \text{ times } 2000$$

or

$$0.0111\ X = 4$$

Therefore, X = 360 lb. of pig iron from Pile A in each metal charge.
1000 minus X = 640 lb. of pig iron from Pile B in each metal charge.
Also, 1000 lb. of iron scrap are used in each metal charge.

Problem II: As soon as the returned foundry scrap collects in sufficient quantity, it will be desirable to include some of this material in the metal charges. If the metal mixture is changed to include 50 per cent of pig iron, 30 per cent of returned foundry scrap, and 20 per cent of purchased scrap (auto. cylinders), determine the weights of pig iron from Pile A and Pile B in each metal charge. Another equation based on the silicon content of the new mixture must be used. The returned foundry scrap will have a silicon content of 1.80 per cent.

The calculations are as follows:

0.0246 X plus 13.5 minus 0.0135 X plus 10.8 plus 9 = 40.
X = 604 lb. of pig iron from Pile A in one metal charge.
1000 minus X = 396 lb. of pig iron from Pile B in one metal charge.
Also, 600 lb. of returned foundry scrap and 400 lb. of iron scrap (auto. cylinders) are used in one metal charge.

In the previous problems, the amount of pig iron from each of two piles was found which would give a definite content of one element, silicon, in the castings. It is possible to derive mixtures which will give definitely two elements, such as silicon and manganese, in the resulting product, provided three lots of pig iron with analyses within a limiting range are available. However, it is seldom necessary to calculate metal mixtures on the basis of more than one element. The metal charges for the cupola are generally apportioned so as to contain a definite amount of silicon, because this element has a pronounced effect on the properties of cast iron.

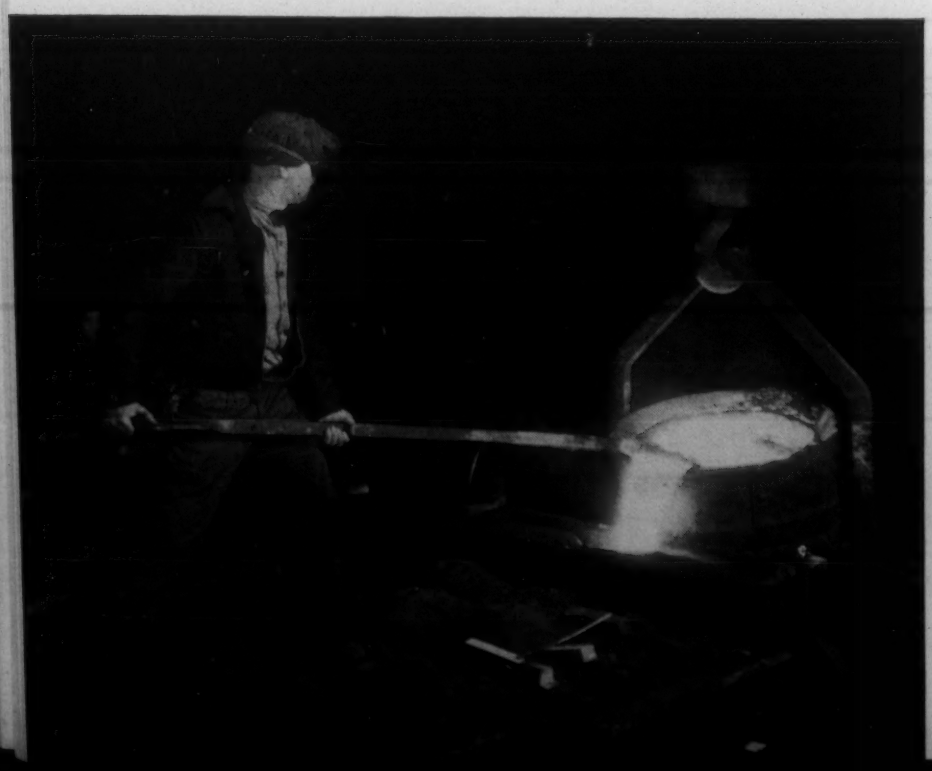
Additions of Special Elements

Special alloying elements can be introduced to cast iron by including them in the charges for the melting furnace or by additions to the metal while it is being poured from the furnace. The alloying materials are supplied to the furnace charges in the form of pigs, lumps, or briquets. High-silicon pig iron known as silvery iron, with 6 to 17 per cent of silicon, and high-manganese pig iron known as spiegel with 15 to 30 per cent of manganese can be obtained for cupola charges. Furthermore, a special pig iron containing chromium and nickel is available for introducing these elements into the cast iron. "Mayari" iron, supplied by the Bethlehem Steel Co., has an average analysis of 2.40 per cent of chromium and 1.20 per cent of nickel, with a wide range of silicon content.

The use of the ferroalloys in briquetted form offers a convenient method for adding special elements to cupola charges. Briquets are now available containing definite weights of manganese, silicon, or chromium. The briquets are prepared from mixtures of the crushed ferroalloys with a cement binder. These mixtures are pressed into definite shapes which serve to identify the specific alloys.

Ladle additions of the alloying elements, or the ferroalloys, can be made with the materials in the form of shot, in a finely pulverized condition, or in the molten state. Since the alloys which are ordinarily added to cast iron have melting temperatures which approach the melting point of the metal to which they are supplied, it is important that the cast iron be superheated to a degree which will permit complete solution of the alloys. Furthermore, the most satisfactory method for adding the solid alloys is to introduce them gradually to the stream of metal as the ladle is being filled. This practice will cause the added material to be effectively stirred into the molten metal.

(Courtesy of Warner & Swasey Co., Cleveland)



Manganese: If the pig iron and scrap metals on hand are too low in manganese to obtain the desired amount of this element in the castings, the manganese content of the metal can be increased by the addition of ferromanganese to each ladle of molten metal. The standard alloy for this purpose contains about 80 per cent of manganese, 7 per cent of carbon, and the remainder of iron. As the melting point (about 2210 deg. F.) of this alloy is relatively high, the ferromanganese should be crushed, preheated, and stirred well into the liquid metal. Under average conditions, about 50 per cent of the manganese added to each ladle of metal is lost through oxidation or directly in the slag.

Nickel: A special alloy of nickel known as "F" nickel has been developed by the International Nickel Co. for ladle additions to cast iron. This alloy contains an average of 92 per cent of nickel, 6 per cent of silicon, and 2 per cent of iron. The particular advantage of this alloy is that it melts at approximately 2300 deg. F., while pure nickel melts at 2646 deg. F. For this reason, it is possible to dissolve the "F" nickel in cast iron which has been superheated above 2400 deg. F. The "F" nickel in the form of shot is usually added to the stream of metal soon after it leaves the cupola furnace. If reasonable care is taken to superheat the cast iron and to distribute the alloy in the metal, the loss of nickel is relatively small.

Chromium: This element is introduced to cast iron either in the metal charges for the cupola or as ladle additions of ferrochromium. A special chromium-bearing pig iron and the chromium alloys prepared in briquet form are available for furnace charges. The alloy which is ordinarily used in adding chromium to molten cast iron contains 60 to 75 per cent of chromium, 2 to 3 per cent of silicon, 4 to 6 per cent of carbon, and the remainder of iron. This alloy has a melting temperature of about 2300 deg. F. Therefore, it is necessary to have the cast iron at a relatively high temperature in order to obtain complete solution of the ferrochromium. The finely pulverized alloy is generally added to the stream of metal as it enters the ladle.

When large proportions of chromium are required in cast iron, cupola additions are more satisfactory than ladle additions. The loss of chromium, due to oxidation will depend upon the conditions under which it is used. In the cupola furnace, the loss may amount to from 10 to 30 per cent of the weight of chromium in the charges. With reasonable care, not more than 10 per cent loss will be incurred when chromium is introduced as a ladle addition.

Molybdenum: The introduction of molybdenum into cast iron is usually accomplished by ladle additions. The molybdenum alloys which are used for this purpose are readily soluble in cast iron at ordinary pouring temperatures. This material is finely crushed and is supplied to the stream of cast iron as the ladle is being filled. Under favorable conditions, the loss of molybdenum when added in this way is relatively small.

Availability of Alloying Elements

When any element is introduced to a bath of metal by means of an alloy addition, the metal in the bath is diluted by the amount of alloy which is added. This

condition requires that more of the special element must be supplied to compensate for the dilution of the bath of metal. Therefore, the full amount of the special element in the alloy will not be available for increasing the proportion of this element in the original weight of metal in the bath. The available content of the special element in any alloy is equal to the percentage of this element in the alloy minus the desired percentage of the special element in the final mixture. This law will now be applied in the solution of several problems.

Problem III: An alloy cast iron having a nickel content of 2.0 per cent is to be prepared by a ladle addition of an alloy containing 92.0 per cent of nickel. Determine the weight in pounds of the nickel alloy to be added to 1800 pounds of molten cast iron.

The calculations follow:

1800 times 0.02 equals 36 net pounds of nickel required.
0.92 minus 0.02 equals 0.90 lb. of nickel available in each pound of the alloy.
36 divided by 0.90 equals 40 lb. of the alloy required.

Problem IV: A chromium content of 0.80 per cent is required in the metal for certain iron castings. The ferrochromium which is on hand contains 70.3 per cent of chromium. Determine the weight in pounds of the chromium alloy which must be added to a ladle holding 1200 lb. of cast iron. Assume that 8 per cent of the chromium which is added to the ladle is lost by oxidation.

Following are the calculations:

1200 times 0.008 equals 9.6 net pounds of chromium required.
0.703 minus 0.008 equals 0.695 lb. of chromium available in each pound of the alloy.
9.6 divided by 0.695 equals 13.8 net pounds of the alloy required.
100 minus 8 equals 92 per cent of the alloy recovered.
13.8 divided by 0.92 equals 15 total pounds of alloy required.

The Use of Formulas in Proportioning Metal Mixtures

The proportions of two lots of metal which will give a desired content of an element can be found by the use of formulas. Let D equal the desired content of the element. Let L equal the content of the element in the lot which has a lower content of the element than desired. Let H equal the content of the element in the lot which has a higher content of the element than desired.

Then $\frac{\text{D minus L}}{\text{H minus L}}$ equals the proportion of the metal from the lot which has a higher content of the element than desired.

And $\frac{\text{H minus D}}{\text{H minus L}}$ equals the proportion of the metal from the lot which has a lower content of the element than desired.

This method for establishing the proportions of two or more lots of metal to obtain a desired mixture will be shown in the solution of the following problems.

Problem V: Find the proportions of low silicon iron containing 1.80 per cent of silicon and high silicon iron containing 2.55 per cent of silicon to obtain an average of 2.40 per cent of silicon in the metal mixture.

By the use of the formulas, the following equations are derived:

$$\frac{2.40 - 1.80}{2.55 - 1.80} = \frac{0.60}{0.75} = 80 \text{ per cent of high silicon iron required.}$$

$$\frac{2.55 - 2.40}{2.55 - 1.80} = \frac{0.15}{0.75} = 20 \text{ per cent of low silicon iron required.}$$

If it is desired to use three or more lots of metal in one charge, mixtures are found for any combinations of two lots, and then any proportions of the different mixtures can be added to give the full charge.

Problem VI: Three piles of pig iron are on hand. Pile A contains 2.82 per cent, pile B 2.22 per cent, and pile C 2.12 per cent of silicon. Determine the weight in pounds of iron from each of these piles for one cupola charge of 2000 pounds of metal having an average silicon content of 2.40 per cent.

With the three different compositions of pig iron on hand, it is possible to combine Pile A and Pile B, as well as Pile A and Pile C to obtain the desired silicon content in the metal mixtures.

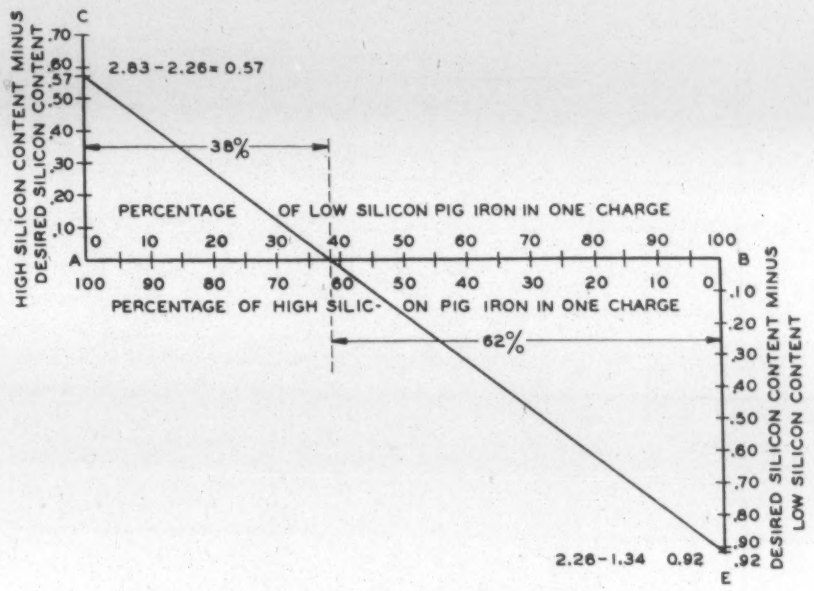


Fig. 1. Graphical Method of Finding the Amounts of Different Lots of Metal for a Desired Mixture.

Using the formulas, the weights of metal from the different piles in the two combinations are as follows:

$$\frac{2.40 - 2.22}{2.82 - 2.22} = \frac{0.18}{0.60} = 30\% \text{ or } 600 \text{ lb. from Pile A } (2.82\% \text{ Si.})$$

$$\frac{2.82 - 2.40}{2.82 - 2.22} = \frac{0.42}{0.60} = 70\% \text{ or } 1400 \text{ lb. from Pile B } (2.22\% \text{ Si.})$$

$$\frac{2.40 - 2.12}{2.82 - 2.12} = \frac{0.28}{0.70} = 40\% \text{ or } 800 \text{ lb. from Pile A } (2.82\% \text{ Si.})$$

$$\frac{2.82 - 2.40}{2.82 - 2.12} = \frac{0.42}{0.70} = 60\% \text{ or } 1200 \text{ lb. from Pile C } (2.12\% \text{ Si.})$$

These mixtures can be combined in any ratios to obtain one metal charge. If one-half of the first mixture is used with one-half of the second mixture, the total charge will consist of 700 lb. from Pile A, 700 lb. from Pile B, and 600 lb. from Pile C. If it is desired to use a larger amount of iron from Pile C, one-fourth of the first mixture can be combined with three-fourths of the second mixture. The total metal charge will then contain 750 lb. from Pile A, 350 lb. from Pile B, and 900 lb. from Pile C.

A Graphical Method for Proportioning Metal Mixtures

A graphical method can be used in finding the amounts of different lots of metal to obtain a desired composition in the mixture. This graph is constructed as follows:

A base line representing the total amount of metal in one charge is drawn on cross-section paper as shown at A-B in Fig. 1. Units corresponding to percentages or pounds of metal are indicated on the base line. Lines are then drawn from points A and B in opposite directions and at right angles to the base line. Equally spaced intervals are laid off on these two lines as indi-

cated. The values given on line A-C designate the differences in percentage of the high and the desired amounts of the controlling element in the mixture. Also, the values given on line B-E designate the differences in percentage of the desired and the low amounts of the controlling element in the mixture. Any straight line joining a point on A-C with a point on B-E will divide the base line in proportion to the distances laid off on A-C and B-E. The application of this graphical method will be shown in the solution of the following problem.

Problem VII: Find the proportion of each of two lots of pig iron containing 2.83 and 1.34 per cent of silicon to obtain 2.26 per cent of silicon in the mixture.

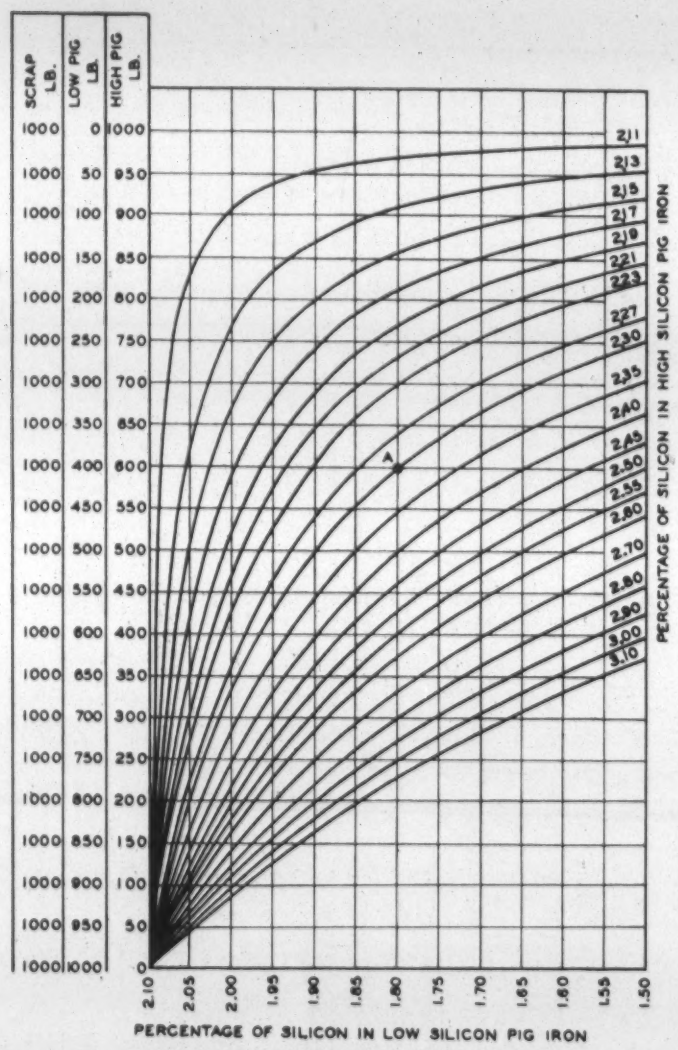


Fig. 2. The Curves are Plotted to Show How to Obtain All Possible Combinations of any Lots of Pig Iron Which Will Have an Average Silicon Content of 2.10 Per Cent.

First, subtract the desired silicon content of the mixture from the silicon content of the higher silicon pig iron. Locate this value on the line A-C. Then subtract the silicon content of the lower silicon pig iron from the desired silicon content of the mixture. Locate this value on the line B-E. Now join the point on the line A-C with the point on the line B-E. The intersection of this diagonal line with the base line will proportion the total amount of pig iron in one charge into two divisions corresponding to the proportions of high and low silicon pig iron in the mixture.

The Use of Charts in Establishing Metal Mixtures

To facilitate the rapid and accurate determination of the metal charges for the cupola, charts can be used from which the quantities of the different metals making up the charges can be read directly. In order to illustrate this method for establishing the weights of metals in the charges for the melting furnace, the following conditions are assumed. Iron castings having a silicon content of 1.65 per cent are required. Each metal charge contains 1000 lb. of scrap iron and 1000 lb. of pig iron. The average silicon content of the scrap iron is 1.56 per cent. Since the total metal mixture must have an average silicon content of 1.83 per cent, the pig iron mixture which makes up one-half of each metal charge will contain an average of 2.10 per cent of silicon.

The curves in Fig. 2 have been plotted to obtain all possible combinations of any lots of pig iron which will have an average silicon content of 2.10 per cent. Using this figure as the origin, decreasing percentages of silicon are laid off on the base line toward the right. Each lot of high-silicon pig iron is represented by a curve. On the left side of the chart, the weights of scrap iron and pig iron for every possible mixture are arranged in columns.

The correct mixture for two lots of pig iron is found by starting with the point on the base line which corresponds to the silicon percentage in the low silicon pig, and following the vertical line to the intersection of the curve which represents the percentage of silicon in the high silicon pig; and from this point of intersection, the horizontal line is followed to the columns at the left where the exact weights of scrap iron, low silicon pig iron, and high silicon pig iron are indicated.

As an example: Two lots of pig iron are on hand containing 1.80 per cent and 2.30 per cent of silicon. Point *A* on the chart in Fig. 2 is the intersection of the line for the low silicon pig and the curve for the high silicon pig. The horizontal line through this point indicates that a full charge will consist of 1000 lb. of scrap iron, 400 lb. of low silicon (1.80 per cent) pig iron and 600 lb. of high silicon (2.30 per cent) pig iron.

If it is desired to use three or more lots of pig iron to a charge, the mixtures are derived for two lots at a time, and then any proportions of the separate mixtures can be combined to give the full charge.

In the preparation of metal-mixing charts, it is first necessary to determine the silicon content required in the pig iron mixtures. This is derived from the desired analysis of the castings, the proportion of scrap to be used, and the average analysis of the scrap. The weights of all possible combinations of the metals are placed in columns at the left, and the silicon contents of the low silicon irons are arranged along the lower edge of the chart. It will then be necessary to plot separately a curve for each of the high silicon irons. The use of metal-mixing charts will simplify the practice and save time in calculating the metal charges for the cupola.

Metal Charges for Other Melting Furnaces

The procedure used in calculating the metal charges for the air furnace and the electric furnace is about the same as that for the cupola furnace. However, the changes in the composition of the metal between charging and pouring vary with the different melting processes. The air furnace is operated with an oxidizing atmosphere, and this condition causes a loss factor for silicon of about 30 per cent and a loss factor for manganese of about 40 per cent of the total amounts of these elements charged. When metal mixtures for iron castings are melted in an electric furnace, an increase in silicon content is sometimes obtained. This is brought about by the reduction of silicates from the lining of the furnace.

Recent Progress in Steel Making Reported from Germany

A Correlated Abstract

By S. EPSTEIN*

GERMAN RESEARCH IN STEEL making has continued to maintain its acknowledged high rank, the past year being unusually fruitful in theoretical and practical results. This is evident from the article in the Feb. 7, 1935, issue of *Stahl und Eisen,* pages 137 to 159, summarizing the activities, during 1934, of the Verein deutscher Eisenhüttenleute. The summary cites exactly 100 references to papers published during that time, mostly in *Stahl und Eisen* and in the *Archiv für das Eisenhüttenwesen.*

Only a few of the papers have been chosen for discussion here, these dealing with the work on equilibria between slag and bath, gases in steel, desulphurization, defects in steel, and some of the recent practical developments.

Equilibria Between Slag and Bath

THE recent work of Körber and Oelsen[1, 2], on the equilibria between slag and melt constitutes an outstanding contribution to the physical chemistry of steel making. In their diagrams depicting these equilibria they have succeeded in giving an unusually clear and surprisingly complete representation of the interrelations among the many variables involved.

FeO, MnO, SiO_2 Slags Saturated with SiO_2 Over Molten Fe

It is a truism that by means of the slag we may control the composition of the steel melt, but ordinary steel-making slags appear so complex that it has heretofore been impossible to represent simply and yet fairly completely how variations in the slag tend to change the composition of the melt, or conversely, how variations in the melt tend to change the composition of the slag. Körber and Oelsen have largely overcome this difficulty by studying the equilibria between C-free Fe melts containing appreciable amounts of Mn and Si, and molten slags over these melts, consisting of FeO, MnO, and SiO_2 saturated with SiO_2. They obtained saturation with SiO_2 simply by melting in silica crucibles.

The saturation value of SiO_2 in such molten slags at steel melting temperatures of about 1600 deg. C. (2900 deg. F.) is close to 50 per cent SiO_2, and this value is but little affected by small changes in temperature, or by variations in the content of FeO or MnO. Such slags are, therefore, composed of about 50 per cent SiO_2 and about 50 per cent MnO + FeO; each of the latter oxides may vary in content from 0 to 50 per cent, but the sum of both is 50 per cent. This is illustrated in Fig. 1.

Fig. 1 shows a diagram of the system FeO, MnO, SiO_2 in contact with molten iron. At temperatures of about 1600 deg. C. the line *ab* represents the saturation values of SiO_2 in the molten oxides. Thus, above the line *ab* there is present the FeO, MnO, SiO_2 melt saturated with SiO_2, plus excess solid silica; below the line *ab* is present the unsaturated molten mix of FeO, MnO, SiO_2. At 1600 deg. C., below the line *ab*, the oxides are entirely molten; above the line *ab* excess solid SiO_2 particles float in the molten oxides saturated with SiO_2. It is the limited solubility of SiO_2 in molten FeO, MnO, SiO_2 at steel-making temperatures which enables sand to be used for the hearth in acid practice.

Now, when a mix of such SiO_2 saturated oxides is allowed to come to equilibrium as a slag over a bath of molten Fe containing some Mn and Si, there are present three phases—molten metal, molten slag, and solid SiO_2. Under such conditions, according to the principles of the phase rule, the relations between the composition of the bath and slag become closely interdependent, and hence can be very simply expressed in spite of the fact that we are dealing with six constituents Fe, Mn, Si and FeO, MnO, SiO_2. The equilibria between the metal bath and saturated slags are such that the content of the bath, for example, in one component say in manganese, at any temperature, fixes the entire composition of both the bath and the slag, at that temperature.

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The Equilibria

Fig. 2 shows Körber and Oelsen's results on C-free Fe melts, containing some Mn and Si in equilibrium with FeO, MnO, SiO_2 slags, saturated with SiO_2 by melting in SiO_2 crucibles. Here we might recall the general convention that ( ) refers to the slag and [ ] to the bath or metal. For example, (FeO) refers to

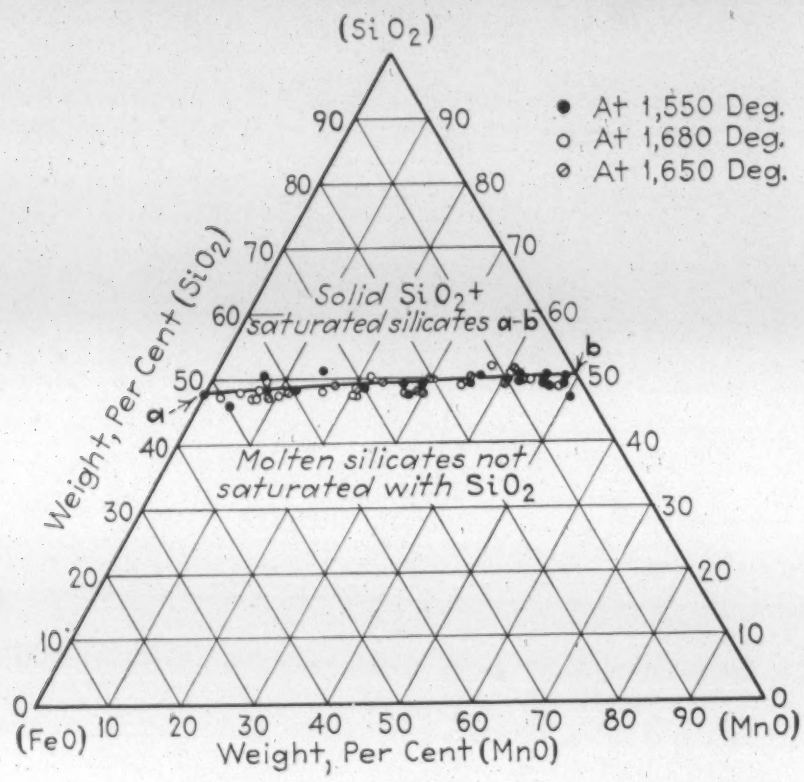


Fig. 1.—The Solubility Limit of Solid SiO_2 in Molten FeO, MnO, SiO_2, in the Presence of Molton Fe. Körber and Oelsen[1]

FeO in the slag, [O] to oxygen in the bath. The curves of Fig. 2 show for any Mn content of the metal, the O content of the metal, the MnO or FeO content of the slag, and the Si content of the metal. Thus for a bath containing 1 per cent Mn the contents of the other components are fixed at 0.13 per cent [O], 0.62 per cent [Si], 5 per cent (FeO), and 45 per cent (MnO).

From the curves of Fig. 2, a deduction may be drawn regarding the low solubility of MnO in liquid steel. It will be noted that as the [Mn] and [Si] go up the [O] goes down sharply; at the same time the ratio of (FeO) to (MnO) also changes sharply. Whereas at the pure Fe end there was much more (FeO) than (MnO), as the [Mn] content increases there is much more (MnO) than (FeO). Thus as [Si] and [Mn] go up (MnO) goes up rapidly; yet [O] also goes down sharply, indicating that [O] is determined mainly by (FeO) and not by (MnO).

Körber and Oelsen have, therefore, concluded that MnO has a very low solubility in liquid steel; the same holds for SiO_2. That the oxygen in the bath is determined almost wholly by the FeO in the slag is an important point, since it indicates that the same relationship would probably exist not only in these particular slags, but also for others, basic slags for example. That such is the case was actually demonstrated by Körber and Oelsen, as will be shown further on.

Effect of Temperature

A more complete picture of the slag-metal equilibria showing five separate isotherms for temperature between 1500 and 1700 deg. C. is given in Fig. 3, which illustrates the effect of temperature on the oxidation-reduction equilibria between slag and melt.

Fig. 3 shows how sharply the deoxidation effect of Mn and Si falls with rising temperature. Thus with 1 per cent [Mn], for example, the [O] is only 0.003 per cent at 1500 deg. C. but rises to 0.02 per cent at 1700 deg. C., this even though the [Si] increases sharply with rising temperature from 0.39 per cent at 1500 deg. C. to 0.75 per cent at 1700 deg. C. This effect is further brought out below in which are tabulated the changes in [Mn], [Si], and [O] with temperature for a constant slag composition of 5 per cent (FeO), 45 per cent (MnO), and 50 per cent (SiO_2), as indicated by section a, b, c, d, e in Fig 3.

Temperature, Deg. C.	[Mn] Percent.	[Si] Percent.	[O] Percent.	Slag
1700	A 1.28	a 1.15	0.016	
1650	B 1.01	b 0.64	0.013	(FeO) = 5%
1600	C 0.74	c 0.32	0.010	(MnO) = 45%
1550	D 0.58	d 0.18	0.009	(SiO_2) = 50%
1500	E 0.45	e 0.09	0.007	

For a fall in temperature from 1700 to 1500 deg. C. but with the slag composition held constant, the [Mn] drops to one-third its former value and the [Si] to one-tenth; yet despite this sharp drop in both [Mn] and [Si], the [O] likewise drops to one-half its former value. This again illustrates that Mn and Si have a much greater power to reduce the oxygen content of the bath at lower temperatures than at higher temperatures.

The other section in Fig. 3 is for a constant [Si] of 0.5 per cent. With a fall in temperature from 1700

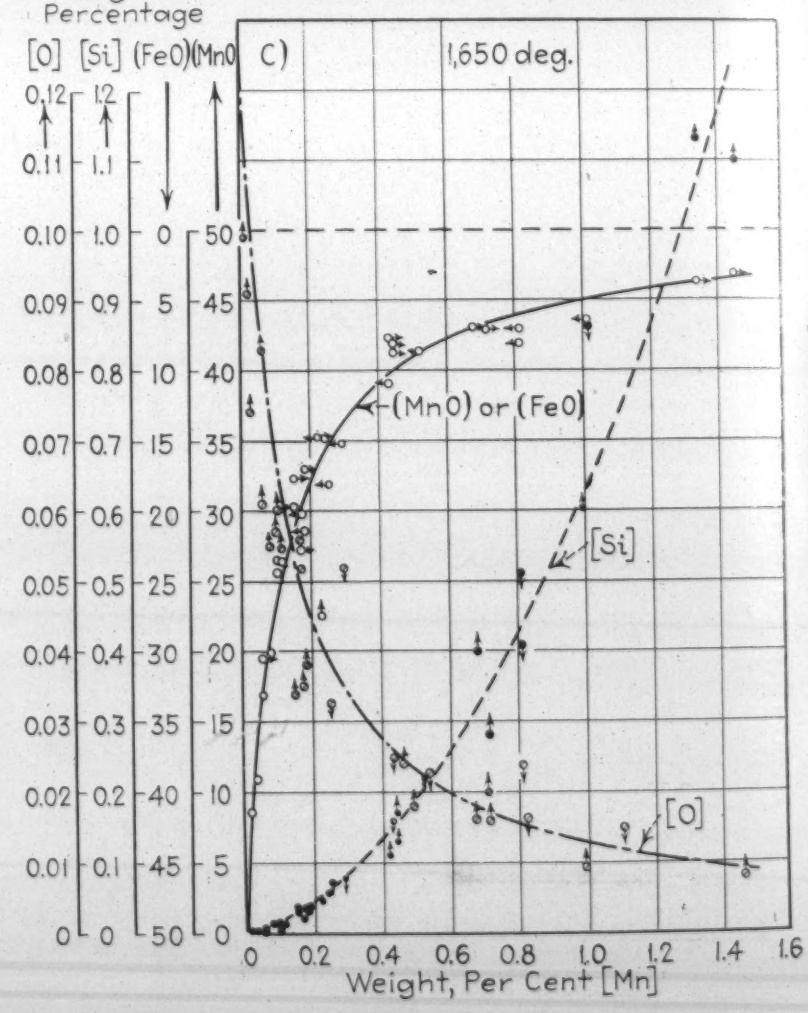


Fig. 2.—Equilibria between Molten Fe and FeO, MnO, SiO_2, Saturated with SiO_2 at 1650 deg. F. Körber and Oelsen[2]

to 1500 deg. C., the (FeO) drops sharply from 8 to 2 per cent, to one-fourth its former value, while the (MnO) increases from 42 to 48 per cent. As the (FeO) drops the [O] drops even more sharply from 0.024 to 0.003 per cent, to one-eighth its former value, while the [Mn] increases only slightly from 0.8 to 1.14 per cent. This again indicates that the FeO content of the slag is the main factor in determining the oxygen content of the bath.

The picture given by Fig. 3 is so comprehensive that

it should prove most useful for reference, if only as a qualitative guide to the oxidation-reduction equilibria between slag and metal and to the effect of temperature on these equilibria.

Production of Fluid Deoxidation Products

We have seen that, as the temperature falls, [O] drops off sharply. This oxygen, which was dissolved

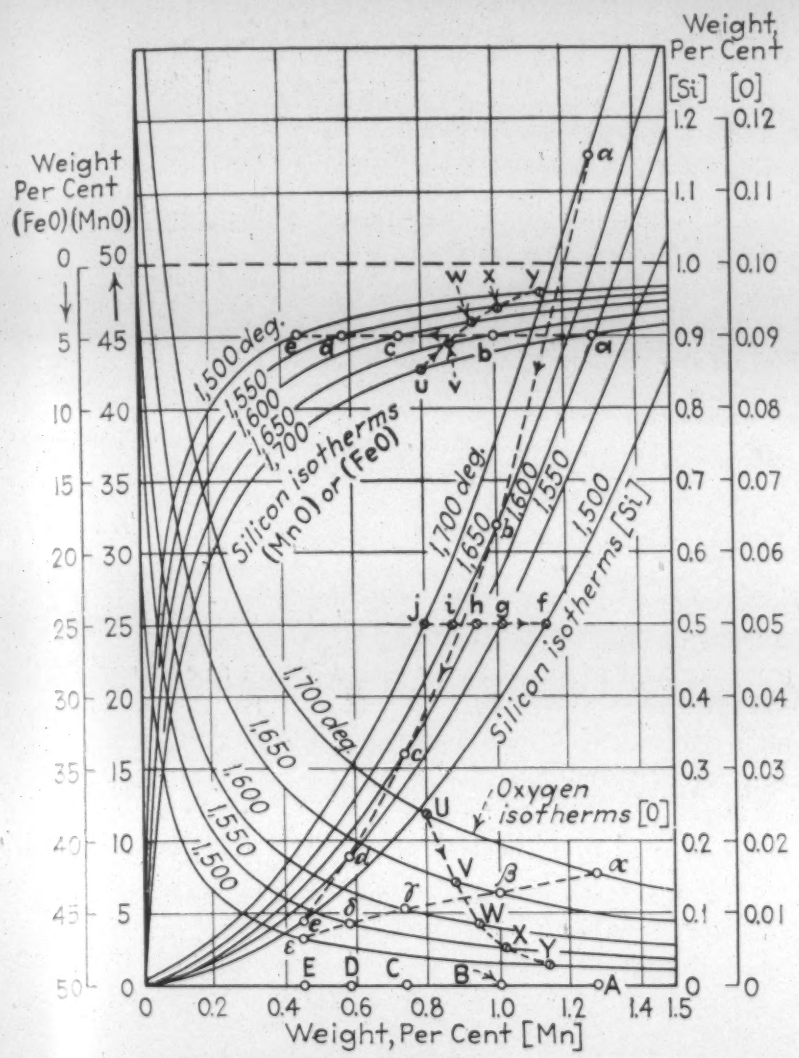


Fig. 3.—The Equilibria between Molten Fe and FeO, MnO, SiO_2, Saturated with SiO_2 at Different Temperatures. Körber and Oelsen[2]
a, b, c, d, e—Section through constant slag composition.
u, v, w, x, y—Section through constant silicon in the melt.

in the metal melt at higher temperatures must separate out as the metal melt cools in the form of an FeO, MnO, SiO_2 conglomerate or as solid silica. Now the Si isotherms shown in Fig. 3 form an important dividing line in respect to the composition of the precipitated oxides. From melts having Mn and Si contents above the Si isotherm, there can separate out on cooling only solid SiO_2; from melts of Mn and Si contents below the Si isotherm, liquid Mn-silicates separate out. It follows that in the field above the Si isotherm, Si is the only effective deoxidizer, Mn not coming into play as a deoxidizer until compositions below the Si isotherm are reached; from here on both Si and Mn work together and form fluid deoxidation products.

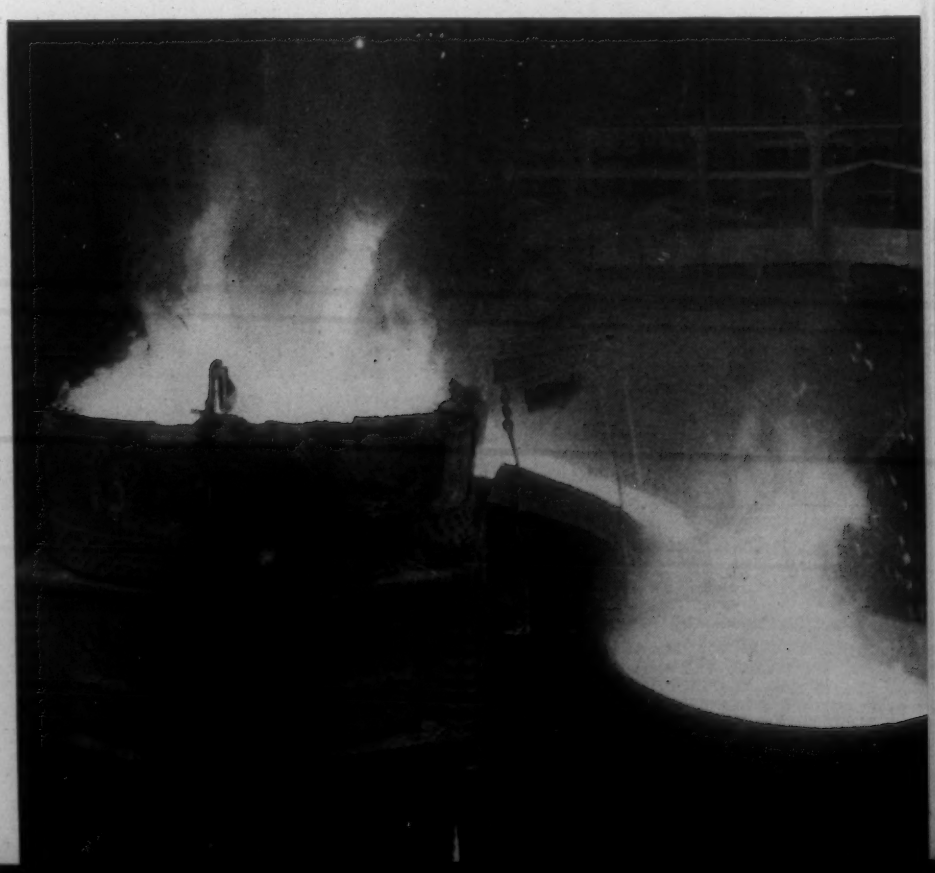
The mode of formation of solid and fluid deoxidation products on cooling of the metal melt is indicated in Fig. 4, showing solid SiO_2 separating out above the Si isotherm, G'F', and liquid silicates separating out below it. However, during the solidification of a metal melt with an original composition above the Si isotherm, the last liquid metal to freeze, may through segregation, attain a composition below the Si isotherm. Fluid deoxidation products would then separate out also from this remaining liquid metal. This is indicated by the melts X, Y, and Z in Fig. 4. As melt X freezes the remaining liquid metal changes in composition along the line AXX', the oxide separating out being solid silica until the point X' is reached when a fluid silicate begins to separate out. By this time, however, most of the metal melt has already frozen, the preparation of liquid to solid being given by the ratio of the lengths of the lines $\frac{XA}{XX'}$, (XA representing the liquid, XX' the solid metal), so that only about 30 per cent of the melt is liquid at the point X'. For the melt Y, however, 55 per cent of the melt is still liquid at the point Y', and for melt Z 80 per cent is still liquid at the point Z'.

Thus, it is obvious that, to enable fluid silicates to separate out during cooling, the composition of the melt must be so adjusted that it is not above the Si isothermal, particularly at the lower Mn and Si contents; furthermore, the course of the Si isothermal is such that a high ratio of Mn to Si content is required. As indicated in Fig. 4, the ratio given by Herty and Fitterer of 4 Mn to 1 Si fits the isothermal fairly well for Si contents of about 0.2 per cent; for lower Si contents a higher ratio of Mn to Si would be required, and for higher Si contents of the metal a lower ratio of Mn to Si would be sufficient. This is the reason why it is possible to obtain fairly fluid deoxidation products in rather high Si steel without adding unduly high amounts of Mn.

Of course, when Si additions are made, high local concentrations of Si occur during the time Si goes into solution, so that particles of solid SiO_2 nuclei tend to form at first, to be surrounded later by fluid silicates. If Si is added before the Mn, solid inclusions will surely form, and the later addition of Mn will have practically no deoxidizing effect. Körber and Oelsen, therefore, recommend adding the Si after the Mn, or adding the Si in two parts, the first with the Mn so that it will surely yield fluid deoxidation products, and then the rest. They also approve of Herty's recommendation to deoxidize with a Si-Mn alloy, high in Mn.

Significance of the Equilibria

Here one may question whether the equilibria of the simplified compositions under discussion apply to commercial steel making. We know that FeO, MnO, and SiO_2 represent only the components of acid, not basic, slag. Even in the case of acid practice, commercial slags contain considerable CaO and Al_2O_3 and may finish with a SiO_2 content of 60 per cent instead of the



postulated 50 per cent in the equilibria discussed*. The presence of C in the metal should also displace the equilibria.

The answer in regard to the composition of the slag is that the equilibria discussed represent the behavior

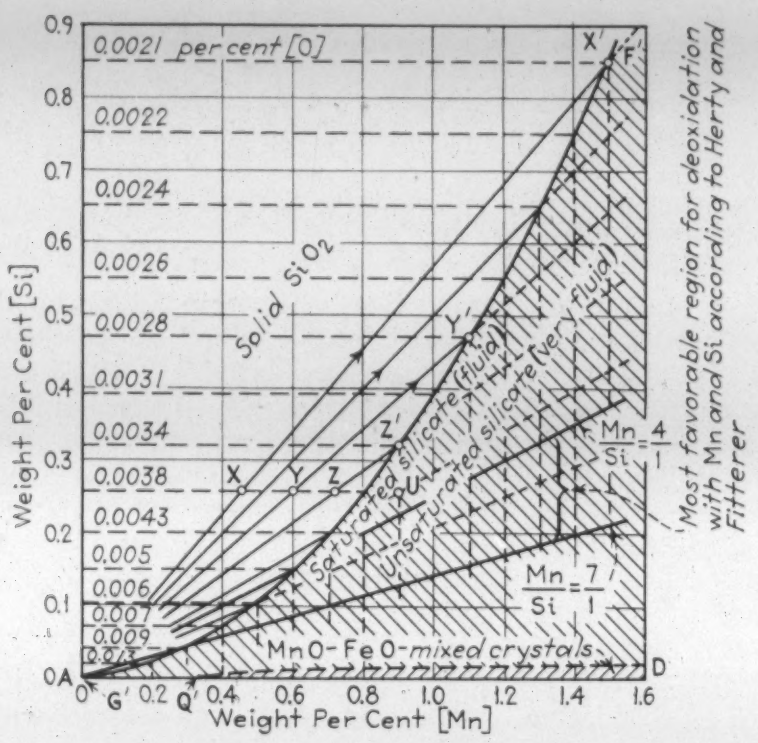


Fig. 4.—Deoxidation Diagram at 1500 to 1520 deg. C. Indicating the Behavior During Solidification. Körber and Oelsen[1]

in commercial steel making rather closely, for both acid and basic practice. Thus the acid slag is essentially the product of the oxidation of the metal itself; in basic melting the meltdown slags before the lime comes up are of nearly the same character as the acid slags. The deoxidizers in both acid and basic practice are mainly Mn and Si, and the deoxidation products or inclusions are essentially the same in both practices —the oxide inclusions in basic steel seldom contain CaO. But the most important point is that the oxidizing effect of both acid and basic slags on the metal bath depends almost entirely on the active FeO content of the slags, so that acid and basic slags are very similar in this respect. This has already been mentioned in the discussion of Fig. 2 and is further indicated in Fig. 5.

In Fig. 5 are shown the O contents of Fe melts at 1600 deg. C. in relation to the FeO content of silicate slags above these melts. The black points are for FeO-MnO silicates in which the FeO is replaced gradually by MnO. The open circles are for FeO-CaO silicates in which the FeO is replaced in increasing amounts by CaO. It will be observed that the oxygen in the melts is very nearly proportional to the FeO content of the slags, and to this alone. Approximately the same ratio of $\frac{[O]}{(FeO)} = 0.0021$ holds for the slags with and without CaO.

Effect of Carbon in the Bath

In regard to the effect of C in the bath, Körber has indicated that two cases may exist, one in which the C reacts very little with the oxides in the bath, and the other in which the C reacts strongly. For the first case of a quiet bath the presence of C, even up to 1 per cent, shifts the equilibria very little, and Körber cites examples of such conditions in acid open-hearth heats. For the second case of a briskly reacting bath, the presence of C produces a condition in the bath, in which the Si is higher than that corresponding to equilibrium—that is, the presence of C tends to reduce SiO_2 to Si.

When the reaction is lively, C reduces the content of dissolved FeO in the bath; this disturbs the equilibria since it results in an increased reduction of Fe, Mn, and Si from the oxides of the slag. Two possibilities come up:

a.—The slag is very fluid and readily becomes homogeneous. Then the loss of oxygen in the bath, resulting from the reaction with C, is quickly made up by absorption of FeO from the slag. In this event, in ordinary steel slags containing over 10 per cent FeO, only a small proportion of the C oxidation results in the reduction of Mn and Si from the slag, because the bulk of the C can react with FeO.

b.—The slag is viscous and becomes homogeneous very slowly, so that only that part of the slag which is in actual contact with the bath may be considered to partake in the reaction. The lower layer of the slag soon becomes impoverished in FeO and MnO, because the latter are reduced by C; solid silica particles, therefore, appear in contact with the bath and further oxidation of C results in a reduction of SiO_2 to Si. When the C reacts very briskly, case *a* may go over to case *b* because of the rapid reduction of FeO and MnO from the slag.

Körber does not attempt to explain why a bath containing C should be inactive at one time and active at another and states that he and Oelsen are studying the deoxidation of steel by C under these conditions and will discuss the whole subject more completely in a forthcoming paper.

Effect of Carbon on Gas Evolution

Graphs such as Figs. 3 and 4 enable us to closely analyze complex phenomena which would otherwise be beyond our grasp; new conclusions inevitably emerge. Thus an analysis of the equilibria under discussion led

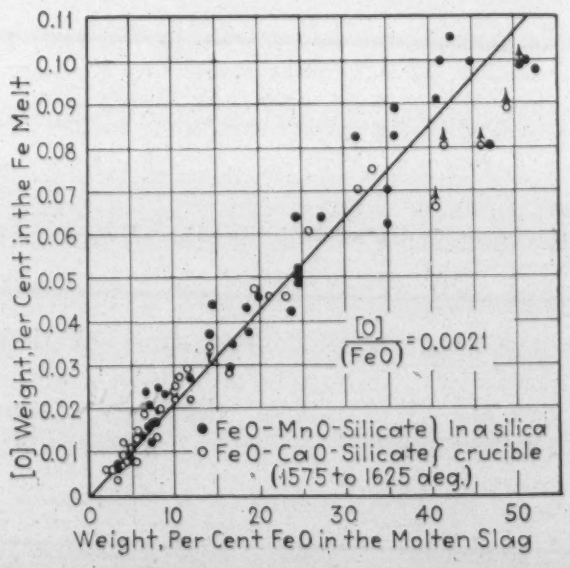

[O] Weight, Per Cent in the Fe Melt
Weight, Per Cent FeO in the Molten Slag
[O]/(FeO) = 0.0021
FeO-MnO-Silicate } In a silica
FeO-CaO-Silicate } crucible
(1575 to 1625 deg.)

Fig. 5.—Dependence of the O Content of Fe Melts on the FeO Content of SiO_2 —Saturated Slags at 1600 deg. C. Körber[2]

Herasymenko and Valenta[3] to propose an interesting explanation of the mechanism of gas evolution in steel during solidification, with special reference, not to rimming steel, but to steel containing considerable amounts of Si and C.

To establish the cause of the quieting or killing of steel, Herasymenko and Valenta observed furnace tests from a large number of acid open-hearth heats. Their results are shown in Fig. 6. It will be observed that the tendency of the steel to evolve gases increased with the content of C; the higher the C content, the more Si was required to completely kill the steel. The authors'

* The higher SiO_2 content of commercial acid slags is due to the presence of CaO and Al_2O_3 which raises the solubility of the SiO_2, and also to the enrichment in SiO_2 when FeO and MnO are reduced by C in the bath.

explanation of the gas evolution was not quite clear but may perhaps be interpreted as follows:

At a temperature of say 1600 deg. C., the liquid steel, before it is poured into the test mold, contains a certain amount of FeO in solution, this depending on the Mn, Si, and C content. The FeO and C in the molten steel have either come to equilibrium or to a point where the reaction between them is very slow, so that there is little or no gas evolution. As the molten steel is poured into the test mold it cools down; this does not change the equilibrium between FeO and C, because this is little affected by temperature. However, as we have seen, the equilibria between [Si], [Mn], and [O] are very strongly affected by temperature. As a result, as the temperature falls, [O] drops sharply, the separated oxygen forming either solid silica or fluid silicates substantially as already indicated in the discussion of Fig. 4. If the composition of the steel is above the Si isothermal, solid silica separates out, and if it is below, fluid silicates are formed.

Now C produces a condition in the bath, in which the Si "isothermal" is raised, thus promoting the formation of fluid silicates (since, beneath the Si isothermal the inclusions are fluid). Since C can react more readily with fluid silicates not saturated with SiO_2 (and hence higher in FeO) than with solid SiO_2, evolution of CO gas is more likely to occur during the solidification of higher C steel. According to the above it is necessary to use more Si to completely kill a higher C than a lower C steel.

This is a particularly interesting conclusion in view of the rather low maximum Si requirement in many specifications for higher C steel, and in view of the necessity of completely killing such steel to get soundness and freedom from inclusions. The above discussion brings out the intimate relationship that probably exists between unsoundness and inclusions. It would seem preferable, in order to insure soundness in steel castings, to maintain a lower C content; if higher strength is required, this might be obtained by the addition of an alloying element such as copper, for example, which would not affect the oxidation-reduction equilibria.

Solubility of Inclusions in Liquid Steel

Sims, in discussing the paper by Herasymenko and Valenta, pointed out that the equilibria shown in Figs. 2 and 3, indicating that fairly high contents of O, Mn, and Si can coexist in liquid steel at temperatures of 1600 deg. C. and above, would seem to support his view that the inclusions found in solidified steel were in solution in the liquid steel and precipitated out only during cooling and solidification.

As we have seen, Figs. 2 and 3 indicate that both MnO and SiO_2 have very low solubility in liquid steel, so that in this sense we may consider that the inclusions themselves are not soluble. On the other hand, oxygen does have a high solubility in liquid steel at higher temperatures, even in the presence of large amounts of Mn and Si. As the temperature falls, the solubility of oxygen drops sharply, the separated oxygen simultaneously reacting with the Si and Mn in the metal to form either solid silica or fluid silicate inclusions. If this temperature drop takes place in the mold, the time before solidification sets in may be too short for the inclusions to coagulate and rise up out of the steel, even if they are fluid. The inclusions which separate out during the solidification period itself, because of the falling solubility of oxygen in the metal during this period (according to the mechanism indicated in Fig. 4), would most probably be entrapped in the steel whether they are fluid or solid.

Thus, it may well be that any favorable effect of holding metal in the ladle before teeming, in diminishing the amount of inclusions in the steel, is mainly through the fall in temperature. That is, it is not so much the case of allowing inclusions which are *already formed* to rise to the top, but rather of creating conditions under which the inclusions that form as a result of the fall in temperature can readily rise up to the

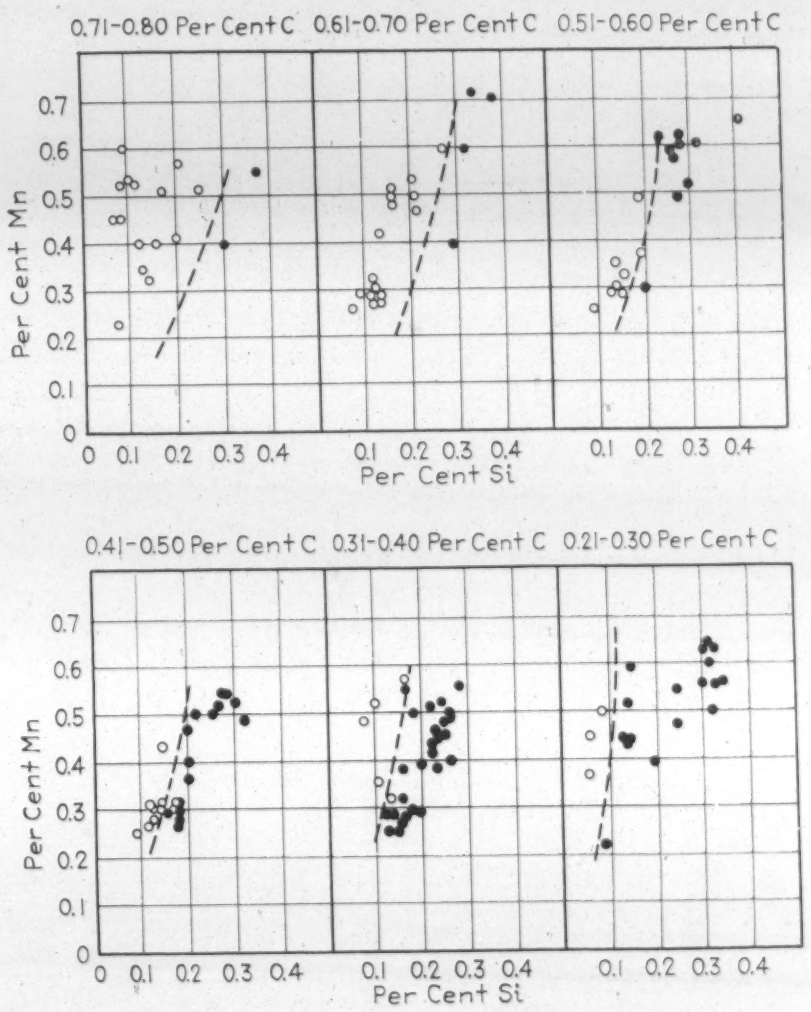

0.71-0.80 Per Cent C
0.61-0.70 Per Cent C
0.51-0.60 Per Cent C
0.41-0.50 Per Cent C
0.31-0.40 Per Cent C
0.21-0.30 Per Cent C
Per Cent Mn
Per Cent Si
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7

Fig. 6.—Evolution of Gas in Furnace Tests from Acid Open-Hearth Heats. Herasymenko and Valenta[3]

Black circles—Completely killed, solidified without gas evolution.
Open circles—Tests showed gas evolution.

slag. According to the above, the last ingot teemed should be cleaner than the first.

From such equilibria as those of Fig. 3 (corrected for the presence of C, which should markedly decrease the solubility of oxygen, particularly at the higher temperatures, and thus radically change the picture) it should be possible to calculate what proportion of the oxide inclusions found in various steels might have arisen because of the difference in the solubility of oxygen between the steel as teemed and the steel as solidified.

(To be continued)

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2. F. Körber. "The Relations of Manganese, Silicon and Carbon in Steel Making—Laboratory Research and Plant Tests." *Stahl und Eisen*, Vol. 54, May 31, 1934, pages 535-543.
3. P. Herasymenko and E. Valenta. "Some Problems of the Physical Chemistry of Steel Making." *Transactions*, American Foundrymen's Association, December 1934, pages 21-47.

EDITORIAL COMMENT

(Continued from page A19)

without injury. Actually it was found that a *few* cycles of overstress *strengthen* some metals slightly.

The American Society for Testing Materials committee on Fatigue of Metals is making a study of this "damage line" and several laboratories are cooperating in this study. Fatigue tests are time-consuming at best, but the determination of a "damage line" takes six or seven times the amount of experimentation that is required for determination of endurance limit alone.

In the April issue of METALS AND ALLOYS, page MA 161 L 9, there is abstracted a paper by Fumio Oshiba of the Imperial University, in which he determines damage due to occasional overstress by noting the reduction of Charpy impact value after a number of cycles of overstress. To produce cycles of overstress, Oshiba uses repeated impact, and consequently it is impossible to translate his results into quantitative stress units. Moreover, his preliminary experiments were carried to a comparatively small number of repeated impacts. His method, however, deserves careful study, both of its technique and its significance, and it might be somewhat less time-consuming to carry out than is the "damage-line" method.

The main point of both of these methods of attack on the fatigue problem is a recognition of the fact that the effect of an occasional overstress of a machine member may be as vital a problem as the determination of the endurance limit of its material. It is hoped that these two methods of study of fatigue damage (and any others which seem promising) may be studied carefully by laboratory workers.—H. F. M.

Metals at Low Temperatures

A step in advance was the organization at the recent spring group meetings of the American Society for Testing Materials of a new committee on Properties of Metals at Low Temperatures. This is a sub-committee of the joint committee of the A.S.T.M. and the A.S.M.E. on the Effect of Temperature on the Properties of Metal. The work of the general committee in the high temperature field has been productive of important researches and results which have been of far-reaching importance in improving several manufacturing processes.

The taking up of this new phase of the subject is fully warranted. There has recently developed large interest in many lines of industry in the effect of low temperatures on metals and alloys. Modern equipment must function today in many cases in sub-normal temperatures as in the liquefaction of gases, in the dewaxing of oils, where airplanes fly at high altitudes as in the substratosphere, and where railroads operate in severe winter climates.

Low temperature has been defined by the committee as any below room temperature or 70 deg. F. This opens up a broad field for investigation but it is in the much lower temperatures where the greatest practical and vital interest lies. Judged by the work of the general committee in the past in its studies of the effect of high temperatures and the benefits thus conferred on industry, it is certain that the new undertaking will in time be as productive of data of value to industries using metals and alloys at sub-normal temperatures.

—E. F. C.

Substitution

THE badges at the meeting of the American Institute of Mining and Metallurgical Engineers used to be of metal, stamped with the initials of the organization and its crossed hammer insignia. Our youngsters used to squabble over which one might wear this decoration when we came back from the meeting.

This year, the badges consisted merely of a celluloid envelope into which the card bearing the wearer's name was slipped. The only metal was the safety pin on the back, not visible. The badges would have been more suitable for a meeting of organic chemists.

Not that it makes any difference, as our youngsters are now far past the age when even a royal purple badge would have any appeal, but the substitution of a cheaper, yet sufficiently serviceable non-metallic product for a metal one, even where sentiment would naturally dictate sticking to the old custom, did interest us.

We can take some comfort from the fact that in this, and certain other uses, the metal safety pin still holds its own!—H. W. GILLETT.

Another Chuckle

N. A. ZIEGLER, of the West Penn Electric Co., sends us the following, from the Electrical Foreign Trade Notes, Bureau of Foreign and Domestic Commerce, Washington, Dec. 15, 1934:

> *Improvements in the Distribution of Electricity:* The first-class quality of electricity in France is that supplied to consumers of continuous current, with non-variable technical characteristics, according to an article written by Mr. Friederich, which appeared in *"L'Usine"* of Oct. 18, 1934.
>
> By "continuous current" electricity is meant that current must be supplied continuously without interruption or breakdowns, at all costs, such as electricity used by surgeons for operating, air ports, etc. Certain electric stations are now equipped with apparatus which cuts off the current as soon as a breakdown occurs and automatically reestablishes it.
>
> By "invariable characteristics" is meant electric current with invariable voltage and frequency, and is indispensable for lamps and motors.
>
> The various categories of electric current used by the average consumer in France may be classed as follows:
>
> As regards voltage: (1) the most popular at present is 115 volts, consumed for most lamps and electric apparatus; (2) 230 volts, utilized for the more expensive electrical apparatus and for lamps with not less than 30 watts; (3) intermediary voltages between 115 and 230 volts.
>
> As regards continuous and alternating current: 50 cycles. These are about equal for lighting purposes. However, continuous current is preferable for motors, being more adaptable and requiring a simpler installation.

With an abstractor who can produce a jewel like this, it would appear that the New Deal professorial tendency has not reached the Bureau of Foreign and Domestic Commerce. We hope that T. V. A.—the "yardstick"—will be given the task of producing the French type of continuous 50-cycle current before the U. S. utilities are forced to produce this "first class quality of electricity!"—H. W. G.

The Development of the Coreless Induction Furnace

No. 10 in a Series of Case Histories in Metallurgical Research

By G. H. CLAMER *

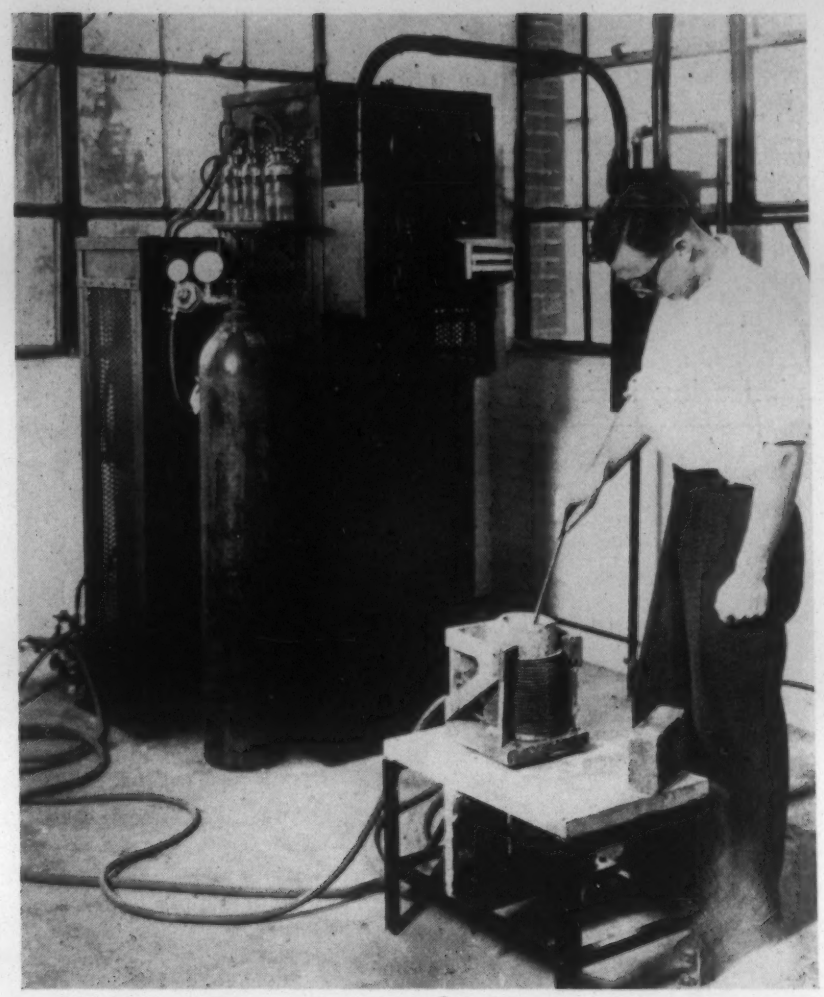

Fig. 1.—A 35 Kv-a. Converter with 17-lb. Furnace for Melting Steel and Other Metals.

IN 1916 WE RETAINED Dr. Edwin F. Northrup, then of the staff of the Palmer Laboratory of Princeton University, to analyze the electric furnace art as revealed by the literature and Patent Office records. Our assignment was the following:

> "Has any basic principle for developing heat by electrical energy been overlooked in the art of electric heating, and if so, has such basic principle promise of commercial application?"

Dr. Northrup, in his report, made after some months of study, stated that in his opinion only one basic principle holding promise of commercial application had not, so far as his researches revealed, been suggested; namely, heating by the use of induced currents of high frequency.

Dr. Northrup had been one of the early workers in the field of communicating intelligence by the wireless method; he was, therefore, experienced in that art. He reported that all previous efforts in the wireless field had been directed toward obtaining higher voltage and higher frequency. Higher voltage and higher frequency were essential for increasing the distance of transmission. No one had, in so far as his investigation revealed, deliberately stepped down the voltage of a high frequency current for the express purpose of using it for heating. There was no prior art revealed in the United States Patent Office records and as a consequence there were no citations against the original patent application. This will be recognized as a unique experience.

As the Patent Office search disclosed no prior art in the field of applying high frequency current for heating purposes, broad patent coverage was allowed, as is evidenced by the following typical claim:

> "The method of applying energy by electro-magnetic induction, to be converted into heat within a resistor mass which consists in passing high frequency current thru a conducting coil surrounding the resistor to be heated."

Strange to say it was not until several years after the grant of this broad and basic patent, and long after the grant of similarly broad patents in nearly all European and some other foreign countries, it was discovered that a patent covering the idea of using high frequency current for heating had been issued in France in 1904 to Schneider. He was also the patentee of the first submerged resistor induction furnace. Schneider was president of the Creusot Works in France and past-president of the Iron and Steel Institute of Great Britain, and, therefore, a man of high prominence in the steel industry.

He may never have built a furnace for operation by high frequency current, or if he did, he no doubt early abandoned his experiments in the belief that no practical use could come of it. Nothing practical was done with heating by high frequency current until Dr. Northrup developed the art into its highly useful and commercially important present state.

It was only as I began to write this Case History that I received the very interesting information from E. A. Colby that he, too, had at a very early date (1892) conceived the idea of using high frequency current for melting precious metals.* He did not, however, patent or develop his idea.

The discovery of the Schneider patent and the Colby evidence of conception after the grant of the Northrup patent would not now establish a state of the prior art of such a nature as to invalidate the Northrup patent claims. Both of these evidences of anticipation

* President and General Manager, Ajax Electrothermic Corp., Trenton, N. J.

* In a letter which I hope may be later published.

fall into the class of abandoned experiments, and therefore, strengthen the claims of the inventor who many years thereafter develops the same to such a state that it is capable of practical and extended commercial use. In 1928 additional broad patents were issued covering the features and proportioning required for building commercially practical furnaces having no interlinkage or only partial interlinkage of iron.

As has frequently happened in connection with pioneering inventions in the past, no practical power

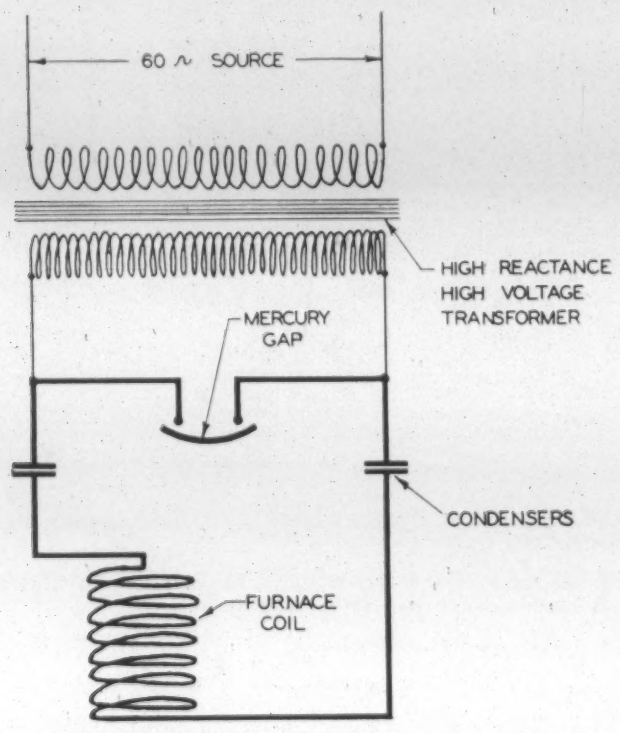

Fig. 2.—Simplified Wiring Diagram of a Converter and Furnace.

equipment at the time was available on the market for successfully practicing the invention; also no suitable condensers were available for power factor correction.

When Fitch operated in the Delaware River the first steamboat, Benjamin Franklin viewed it from a dock in the city of Philadelphia. Franklin was a scientist and an inventor; he was noted for his open and flexible mind, and yet to indicate how perfectly human he was in the fallibility of his judgment, he declared, after having seen it, that steam navigation could never compete with sails. In his judgment, the capital expense, the layout for upkeep and the amount of room in the hull pre-empted by the power plant were so large as to make steam propulsion impractical.

Sir Isaac Newton in 1680 recorded the thought of using the power of steam for propelling a carriage, but promptly rejected it as being impractical. Newton contemplated the use of the reactive power of a jet of steam against the boiler in which it was generated. Cugnot, in the reign of Louis XVI, first had the audacity to build a cart driven by a steam engine. James Watt, inventor of the separate condenser that was the first step toward making the Newcomen steam bellows, a practical steam engine, would not subscribe to the idea that a steam engine could be empowered with locomotion. Trevithick, Vivian, Blenkinsop and others persisted and finally a power plant was produced capable of practical application in the transportation field.

Langley, the inventor of the airplane, did not have a practical engine with which to fly it. Curtiss later installed a then modern engine in the Langley plane and made a short flight with it.

A Converter the First Power Equipment

The first power equipment devised for operating high frequency furnaces we have designated as a "converter," Fig. 1. It is the means by which the frequency of the supply line is stepped up to the frequency needed at the furnace terminals. Converters of single phase can be made in sizes from a fraction of a Kv-a. to about 35 Kv-a. capacity and in multiphase or otherwise varied forms they may be made in larger sizes. The circuit is oscillatory.

A simplified wiring diagram is shown in Fig. 2. The equipment consists essentially of three pieces of apparatus, a high reactive transformer, a spark gap and a bank of condensers. These, in conjunction with the furnace coil, set up an oscillatory circuit. The frequency of oscillation is a function of the capacity and inductance of the oscillatory circuit and in practice ranges from about 20,000 to 60,000 cycles per second.

The early work in connection with that art, which is now generally known as the "high frequency coreless induction method of heating," was carried on in the Palmer Laboratory at Princeton University by Dr. Northrup and his assistants, and with the permission and co-operation of the Princeton authorities.

At first an open rotary spark gap was used to produce the required high frequency oscillatory current. The discharge of this gap sounded like an infantry charge. I frequently went to the Palmer Laboratory to discuss the progress of the work. Long before I reached the laboratory I knew by the terrific noise emanating from it that the equipment was in operation. When the laboratory was reached the sound became almost deafening.

The present discharge gap, Fig. 3, consists essentially of a double wall container for holding a bath of mercury and having space above the pool to afford room for the electrodes. The purpose of the double walls is to provide space for circulating water for cooling purposes. The electrodes, too, are provided down to the arcing tips with water cooling means. The arc operates in a sealed chamber between a tungsten-tipped, copper electrode and the mercury bath. An atmosphere of pure hydrogen is maintained in the

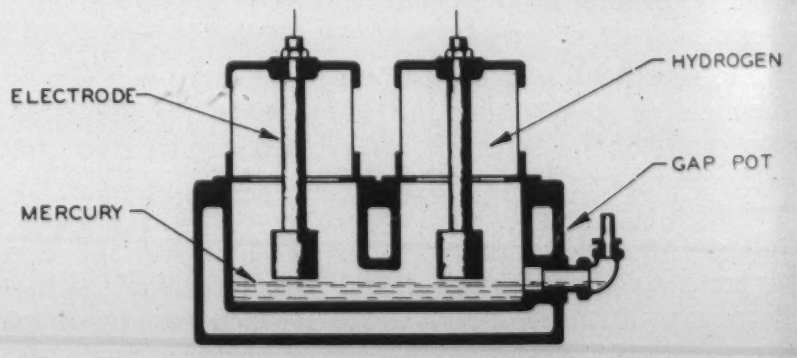

Fig. 3.—Section of Modern Discharge Cap. Electrodes and Pot are Water-cooled.

chamber. Means are provided for adjusting the level of the mercury whereby, by varying the distance between the electrodes and the mercury pool, the power is controlled. Such a discharge gap is not only quiet but is highly efficient and effective.

The gaps were made originally with iron electrodes with graphite tips and were air cooled. The first decided advance was made when water-cooled, copper electrodes were substituted. The next important im-

provement was the addition of hydrogen instead of alcohol vapor at the suggestion of Glenn D. Bagley. At the present time the water cooled copper electrodes with tungsten-copper tips are used in all our converters.

More recently a gap hermetically sealed in a glass container has been provided for the lower powered equipment; namely, 7½ Kv-a. and under.

Development of Capacitors

Condensers are, of course, required in the oscillator circuits, and they are also required for the larger commercial units. In this latter case they are used to correct the power factor of the furnace. When we began our development work, as previously stated, no commercial condensers, now known as "capacitors," were available on the market. Dr. Northrup was, accordingly, obliged to make his own capacitors. He constructed them of alternate plates of proper quality glass and very thin brass sheets. These were immersed in water-free oil. Capacitors so made were heavy, costly and decidedly inconvenient for handling. I do not believe that high frequency heating could have become a commercial realty, had it been necessary to adhere to the use of such capacitors.

The radio art was then in its infancy and mica condensers for use in radio circuits were being developed. These were tried and, although superior to our own capacitors, were not sufficiently durable in the service of high frequency circuits to fill the requirements and were relatively very costly.

The General Electric Co. was then engaged in the development of the impregnated paper and aluminum foil type of capacitor, Fig. 4. These, fortunately for

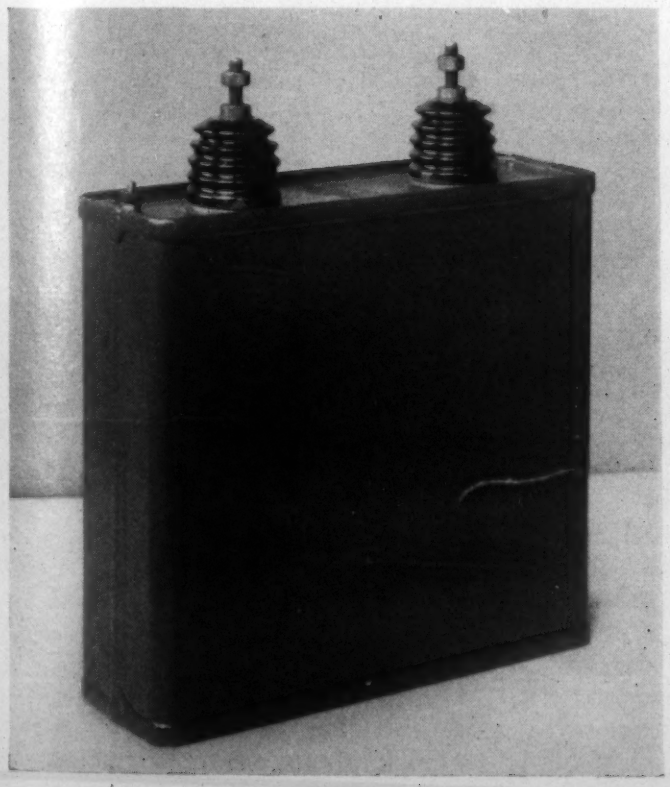

Fig. 4.—Capacitor as Used with Modern Commercial Coreless Induction Furnace Equipment.

us, were soon to be placed on the market for correcting the power factor of commercial circuits. We had the splendid co-operation of the General Electric Co. engineers in developing a capacitor of this type to meet our difficult requirements.

These capacitors are in units of such size and shape as to make them conveniently transportable and are sealed so the oil cannot escape. The capacitors are now placed in metal tanks filled with transformer oil

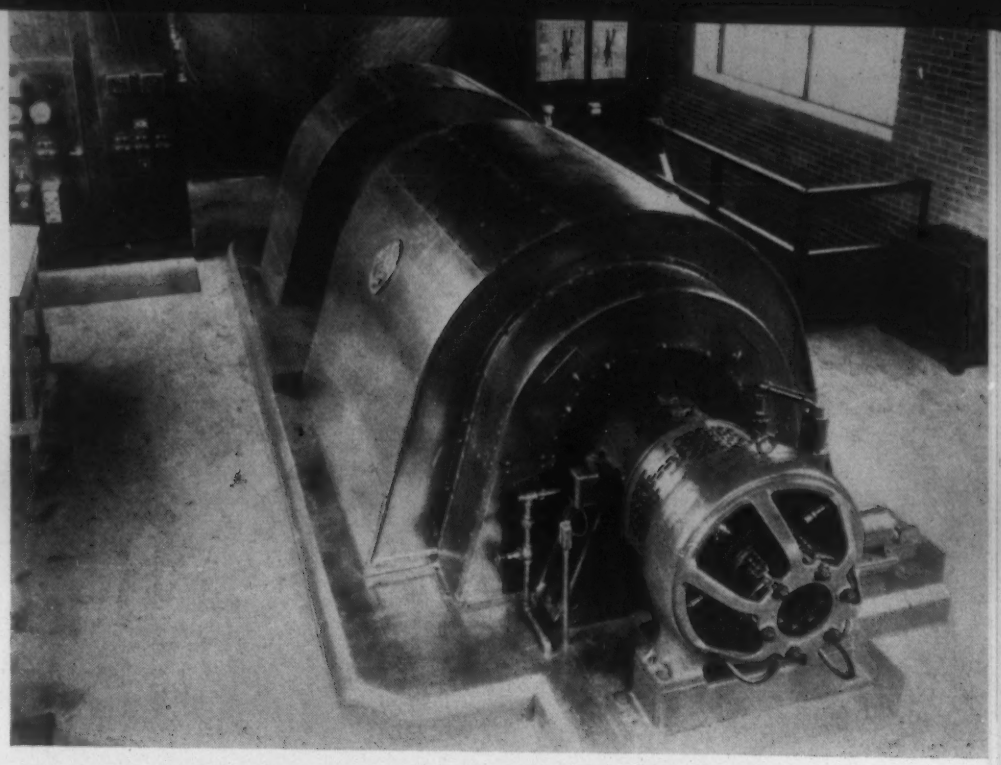

Fig. 5.—A 1200-Kw., 1000-Cycle Motor Generator Used for Energizing a Four-Ton Steel Melting Furnace.

and are kept cool by water cooling coils arranged inside the tanks. Before a means for cooling the capacitors was adopted, breakdowns occasionally occurred. With avoidance of excessive overloading in use, it is now a rare occurrence to have a capacitor failure. The evidence is that the life of capacitors under such operating conditions will compare favorably with that of power transformers.

The dimensions of the bank of condensers of the original glass and brass type required for a 35 Kv-a. converter was about 23 cu. ft., as contrasted with 5.2 cu. ft. for the capacitors now used.

The Westinghouse Electric & Mfg. Co. is now also producing highly satisfactory capacitors of this type, suitable for power factor correction of coreless induction furnace circuits.

Further improvement in capacitor operation is confidently looked for in the use of "Pyranol" in place of oil, the improvement resulting due to the use of Pyranol being a reduction in bulk and an increase in the already long life of operation. Researches connected with the use of Pyranol in the manufacture of capacitors are being conducted by the General Electric and Westinghouse companies.

Converters in Commercial Use

Robert H. Leach, of the Handy & Harman Co., was the first to back his conviction that the high frequency furnace was useful for commercial melting. He had a baffling problem in connection with silver melting that he believed could be solved by the use of a high frequency furnace. Medium frequency generators were not yet known to be applicable to commercial melting and the higher frequency Alexanderson type alternators were prohibitively costly. We supplied a three-phase spark gap converter. With this he melted silver satisfactorily but did not for many years thereafter solve his problem. His problem was to secure freedom from porosity in the cast slabs.

Mr. Leach is to be congratulated in that through concentration of effort and scientific approach he finally solved his metallurgical problem. This was the first commercial installation. Our experience with this gave us courage to proceed further. We shall always feel grateful to Mr. Leach and his associates for this first big lift.

The Ajax-Northrup spark gap converter is credited with a score or more of new processes and developments, such as the heating of metallic parts within thermionic tubes, used in the X-ray and radio arts;

and Permalloy, a development of the Western Electric Co., which speeded up some six times the transmission of messages in undersea cables.

Converter units are now in use in practically all the major research laboratories in the United States and many are in use in foreign lands. Commercial uses are developing for spark gap sets because of the ability to heat quickly small conducting bodies to a high temperature in a controlled atmosphere or vacuum. Heat may be applied to defined portions of a conducting body. High temperature not possible by other means may be controlled in a non-carbonaceous atmosphere. Temperature is under positive control because heat is generated within the body to be heated. The power input is easily and definitely regulated by

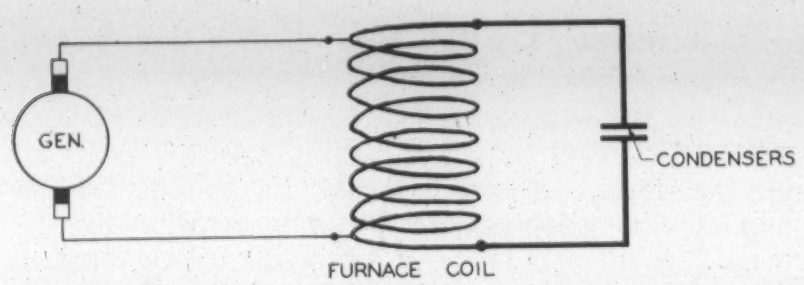

Fig. 6.—Simplfied Wiring Diagram of a Generator Operated Furnace.

the turn of the hand, or it may be made automatic through the use of the photo-electric cell or other means.

We early realized that the use of oscillatory current in practice was restricted to an output of approximately 35 Kv-a. per phase. Polyphase high frequency power circuits are possible but complicated, and often are more or less unsatisfactory. Several such units having higher power rating than 35 Kv-a. are, however, in use. Satisfactory vacuum power tubes of large capacity are not yet available. The Poulsen arc is inherently inefficient and unsatisfactory for commercial furnace use. We, therefore, turned our attention to the use of rotary high frequency generators, Fig. 5. A typical circuit for this type of equipment is shown in Fig. 6.

Use of Medium Frequencies

The only high frequency generator of the rotary type at the time was the kind used in radio sending stations. These machines delivered current of much higher frequency than required for furnace work. They were also so expensive as to preclude consideration for such service. These generators sold at roughly fifteen times the price of those at present used.

About 1923 Dr. Northrup, as a result of tests made at the plant of the National Machinery Co., Tiffin, Ohio, proved that medium frequencies of 500 to 2000 cycles were suitable for most commercial applications of inductive heating. Machines of this frequency range could be built in any size and were so much less expensive as to make them practical from an economic standpoint. The General Electric Co. staff by this time began to visualize the future possibilities for the coreless induction method of heating and authorized their engineers to co-operate with us in designing rotary generators that would meet our requirements. As a result of their enlightened experience and fine co-operation, coupled with their splendid facilities, a very satisfactory salient pole type of generator soon was developed. Inductor type generators for the higher frequencies are now also available.

We purchased a 150-kw. motor generator set from the General Electric Co., consisting of a three-phase motor and a single-phase generator developing current at 900 volts and 2000 cycles. This initial set has been described many times.* It was put in operation in 1926 and was used for the commercial production of a magnetic alloy for transformer manufacture. The commercial possibilities for the extended use of high frequency heating could not have been demonstrated without an investment of this kind. This equipment has operated satisfactorily from the start. It is still in daily use and has made it possible not only to study the innumerable applications of high frequency heating but to improve in detail furnace design, circuits, methods of shielding, lining, etc. It has also been possible to demonstrate the usefulness and effectiveness of high frequency heating to prospective users for melting, refining, or heat treating special products.

Early Pioneering in Melting

Isaac Harter, vice-president of the Babcock & Wilcox Co., was the first in the steel industry to back his conviction with the purchase of a high frequency coreless induction furnace. His company has for nearly ten years operated one of the outstanding installations of high frequency furnaces in the world. Dr. Comfort A. Adams, who holds the chair of electrical engineering at Harvard University, after consultation with Dr. Northrup, was largely responsible for the designing of this splendid installation.

J. R. Coe, of the American Brass Co., was quick to visualize the value of the high frequency furnace to the wrought brass industry. His company not only backed his judgment by the purchase of equipment, but acquired exclusive rights for the use of the same in that industry. Since then an arrangement has been made by which we can supply furnaces to this same field. The initial installation of 1200 kw. was made in 1925, and that company now operates in its several plants a total of 26 furnaces, requiring 2600 kw. These furnaces have a total daily capacity of 155 tons. The high frequency furnace is used by the American Brass Co., in conjunction with its many Ajax-Wyatt submerged resistor induction furnaces because of its flexibility; namely, each melt is a unit and any kind of pure metal or alloy may be melted in it. To Messrs. Harter and Coe we owe a great debt of gratitude.

Some Modern Installations

Many installations have been made since these pioneering ones, not only in the United States but in practically all the countries of Europe; there are also many installations in Japan.

A majority of the commercial installations, thus far made, are melting alloy steels of the stainless, heat and corrosion resisting types, resistance alloys and tool steels. The furnace is particularly suited to the reclaiming of stainless steel scrap because it melts without carbon pick up and without appreciable loss of chromium or nickel. In the melting of tool steels, particularly of the high speed types, the inherent stirring of the furnace prevents tungsten or cobalt segregation and yields exceptionally clean and homogeneous metal.

A number of units are being used for the odd brass alloys and the high copper mixtures, and several units are in service for melting pure and sterling silver. One of the particular advantages of this type of fur-

* *Metal Industry*, January, 1927.

nace is that the technique can be worked out with a small laboratory size and then transferred to the production size units without change. The high frequency furnace is fast-melting, which means that rush orders can be gotten out without delay, without the necessity for large inventories of special metals.

D. F. Campbell, of the Electric Furnace Co., Ltd., of London suggested that a plant could be built and operated at a lower cost using coreless induction furnaces exclusively, than by using arc or open-hearth furnaces. He points out that smaller handling equipment and molds and lighter and smaller buildings require less initial investment. Such a plant has now been installed at Hall & Pickles, Ltd., Sheffield, England, and is operating very successfully. The Hoskins Mfg. Co., in this country, melts its chromel alloys exclusively in the coreless induction furnace.

One furnace of holding capacity of six tons and several with holding capacity of four and five tons are in operation (see Fig. 7); eight to 10-ton furnaces are projected. From the theoretical and engineering standpoint furnaces of much larger capacity are possible. The installation of larger units merely awaits a bona fide order.

The Electric Furnace Co., Ltd., of London was early appointed our selling agents for the British Empire except Canada, and also for France and Belgium. Later this company acquired a manufacturing license and has since supplied both converter and generator equipments. More recently it has also handled the Scandinavian territory in co-operation with other licensees. Allgemeine Elektricitats Gesellschaft and Siemens & Halske are licensed to make and sell equipments in central Europe, Spain, Italy and Russia. Co-operative arrangements have also been made between the Electric Furnace Co., Ltd. and Metropolitan Vickers, Allmanna Svenska Elektriska Aktiebolaget of Sweden and the Societe Generale d'Applications Electro-Thermiques of France. Shibaura Engineering Works and Mitsui & Co. make and sell the equipments in Japanese territory. All of these associates have contributed to the development of furnaces and equipment.

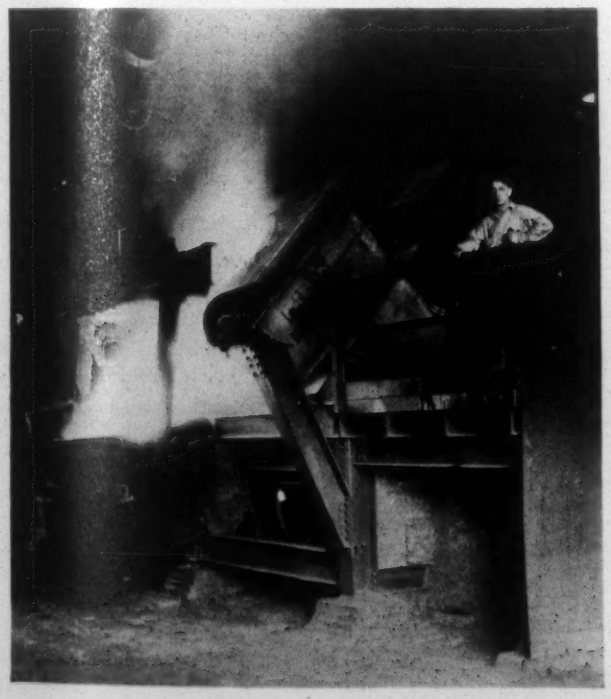

Fig. 7.—A 4-ton Coreless Induction Furnace Pouring a Charge of Alloy Steel.

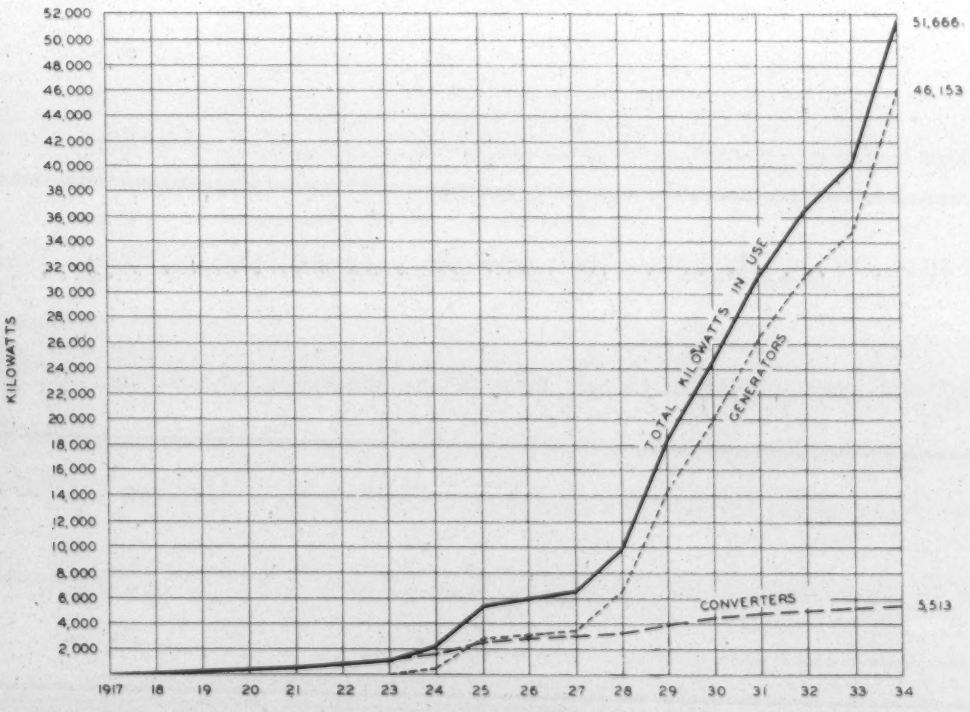

Fig. 8.—Curve Showing Increase in World Use of Ajax-Northrup Induction Furnaces.

Normal Frequency With Partial Interlinkage of Iron

Several attempts have been made to develop a successful furnace using normal frequency with partial interlinkage of iron. Experiments along these lines have been conducted by the Hirsch-Kupfer Co., in Germany, and by the Babcock & Wilcox and the Westinghouse Electric & Mfg. Co. in this country. Great sums of money were expended on these experiments. The conclusions reached, after making comparison of the operation of the line frequency furnaces with the high frequency furnace are the following: (These reasons apply equally whether flat or curved coil construction or solenoid coil construction is used.)

(1) A heel of hot metal must be left in such a furnace, as is also necessary in the submerged resistor type of normal frequency furnace, or else a large lump of cold metal must be used for starting. To start a furnace in such manner is a slow and difficult operation.

(2) As the net power factor is very low, the cost of the furnace, together with the cost of the capacitors for necessary power factor correction, is greater than that for the high frequency furnace with its frequency changer, capacitors and control.

(3) The efficiency is definitely lower than that of the high frequency furnace.*

(4) Turbulence of the bath is great. If power is reduced to give a flat surface, then insufficient power is absorbed to hold temperature.

(5) Flexibility of electrical and temperature control of the furnace is decidedly inferior.

In the meantime, approximately 1000 submerged resistor furnaces, operating on circuits of line frequency and using interlinkage of iron with primary coil, are in successful use for non-ferrous work. Such furnaces have been in successful use for many years. These furnaces operate with high efficiency and with such high power factor that power factor correction is seldom resorted to.

By reason of recent improvements on this type of furnace, there is promise of its use being extended into wider fields and in greatly increased unit sizes. It appears to me that the submerged resistor type of furnace for liquid ferrous metal holds more promise for commercial success for operation on normal frequency lines than a furnace with partial or no interlinkage of iron with the primary coil.

Rapid Spread of Use of Coreless Furnaces

The use of coreless induction is now spreading into fields other than that of melting and refining molten

* Paper by Dr. C. A. Adams entitled, "High Frequency Induction Furnace" presented before the A.I.E.E., January, 1934.

metals. It is being applied to heat treatment of solid metal and to various other purposes, such as drying of non-metallic coatings upon a metallic base and for heating metallic containers used in the chemical industries. It is apparent that a great field will develop in differential heating for hardening, annealing, heating for forging, boosting temperature in a production line, etc. Localized surface hardening while maintaining a soft tough core appears very promising for rolling mill rolls, bearings and automotive parts. A number of installations for the purposes listed above are in daily commercial operation. Fig. 8 shows the world-wide growth of coreless induction heating.

Commercially practical furnaces having no interlinking or only partial interlinkage of iron with the primary coil, and using any frequency must be properly proportioned and designed in respect to the frequency used and the resistivity of the charge. This discovery was made by Dr. Northrup after much experience in the field and after having made a careful theoretical study and analysis of the subject.* His discoveries are revealed in patents previously referred to, which were issued in 1928. By following the teachings of these patents it becomes possible to design successful furnaces of any capacity and for operation on lines carrying currents of pure sine wave form having frequency within the range of rotary alternators of standard design. These patents give broad protection until 1945 covering commercially successful furnaces of the coreless type.

A great many minor patents have been issued to Dr. Northrup and others of our staff covering either details of construction or application of the coreless induction method of heating. Other patents have been acquired by purchase or rights under them have been acquired. Some of these are essential for success; others have been secured merely for defensive reasons. As is natural, when an art is being aggressively developed, a continuous stream of patents is in the application stage also.

Much has been written on the subject of the coreless induction furnace and its applications and performance. A bibliography is appended. The development of the coreless induction furnace has extended over a period of nearly twenty years. During that time a vast sum has been expended, not only in this country but abroad. It is not possible to evaluate directly the saving resulting due to the use of this type of furnace as I did in my Case History* on the submerged resistor induction furnace; this for the reason that its use is dependent not only on economy of operation or other savings to be effected by its use, but because it presents a novel method, capable of conducting heating operations or accomplishing end results not possible by other methods. The application of the coreless induction method of heating is still in its infancy.

* *General Electric Review*, April, 1928.

* METALS & ALLOYS, November, 1934. Page 242.

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(Concluded on page 133)

Preparation of Lead and Lead-Rich Alloys for Microscopic Examination

By W. H. BASSETT, Jr.* and C. J. SNYDER†

THE SOFTNESS OF LEAD and lead-rich alloys makes the satisfactory preparation of specimens for microscopic examination difficult because the surface metal flows and forms a layer of cold worked metal that masks the true structure. All authorities agree that it is about impossible, even with the most careful preparation, to obtain a surface entirely free from cold working.

Corroded Lead Covered Power Cable Removed from Service for Micro Examination of the Lead Sheath.

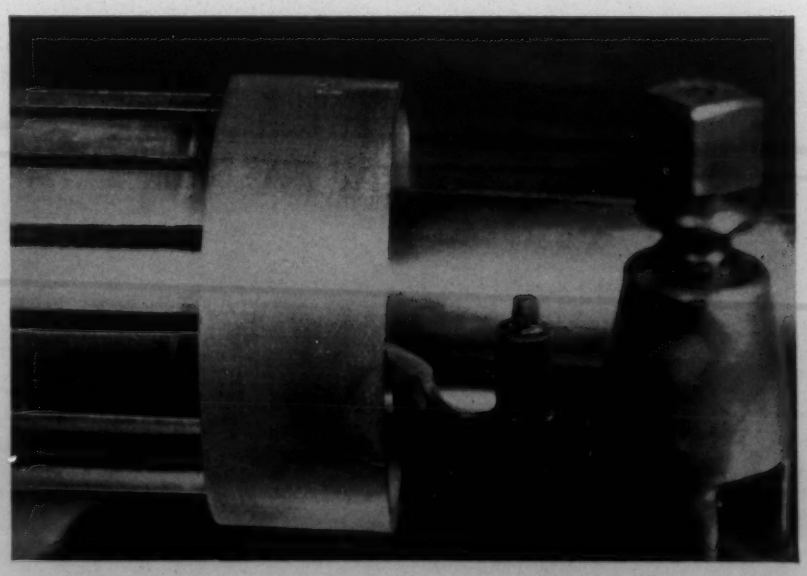
However, recent developments in etching have simplified the task for common leads and for some alloys containing only small amounts of other elements that are in solution. For them it is no longer necessary, and, in fact, is of no advantage to obtain a polished surface, as a comparatively thick cold worked layer can be evenly and satisfactorily removed by etching. Alloys containing hard constituents present a more difficult task because of the uneven attack of etching solutions.

Method of Preparation

VARIOUS methods of preparation for each class of material can be used. For leads, either cutting or grinding will be satisfactory but for alloys containing hard constituents out of solution special microtome cutting as done by Lucas[1] or a method that leaves the thinnest possible layer of worked metal for removal by etching will be advantageous. The size and shape of a specimen may also be a factor in selecting a method of preparation. It is obvious that the same method would present difficulties if used to prepare a cross sectional surface of a large diameter pipe, a 100-lb. pig of metal, or a ⅛-in. thick sheet. The pipe should of course be examined without splitting and flattening as such bending would destroy the original structure.

When preparing a specimen it is always necessary to remove a sufficient depth of metal from the surface to eliminate the effects of sawing, shearing, filing or whatever means was used in taking the specimen to be examined.

Machining a Cross Section of Lead Cable Sheath for Micro Examination. The tool is a right-sided diamond used for facing with the cutting edge set approximately 5 deg. to the plane of the section. Its motion is toward the front. Speed is 220 r.p.m. for 2½ to 3 in. diameter. Feed, 100 cuts per inch.



Cutting

Cutting of lead surfaces for examination has been done on a microtome, on a machinists' lathe, or by hand with a sharp wood chisel or plane. Schumacher and Bounton have used a biological microtome[3] but Lucas, who originated the idea, recommended a rigid wood sectioning instrument.[1] It is necessary that the knives of the microtome be sharpened correctly and that very thin shavings, not over two microns, be cut.

A number of cable manufacturers use a machinists' lathe for preparing lead sheath and other specimens. The cutting edge of the tool should be pointed and shaped so that it cuts and does not flow the metal and the cutting speed and feed should be slow. Proficiency in machining will be indicated by lack of burr at the edge. Pipe or cable sheath samples are best supported on an expanding mandrel and solid samples in a regular chuck.

When using a wood plane, the sample is clamped between two boards and the whole mass shaved away together. The plane blade should be sharp and the shaving as thin as possible. These methods are intended to produce a surface suitable without further treatment for etching for low power examination and, when properly done, will produce surprisingly good results.

Grinding

When fine work is desired, the cut surface, after preliminary etching, should be ground smooth and flat on lubricated 4/0 Fischer emery paper, backed by plate glass as explained under grinding, after which a light etch will produce a smooth surface.

When the samples have not been carefully cut on a machinists' lathe, Bassett and Snyder prepare lead surfaces exclusively by grinding.[5] The use of regular polishing equipment is undesirable as it drags the metal. A specimen is filed sufficiently with a milled file to remove all traces of other working and to make the surface flat. The surface is then ground smooth by rotating by hand on lub-

* Technical Superintendent and Metallurgist; †Assistant Metallurgist, Anaconda Wire & Cable Co., Hastings-on-Hudson, N. Y.

Photomicrograph of Cast 2 Per Cent Bismuth Alloy. Etched with Reagent No. 2. Magnification, 6.5 diameters.

ricated emery paper which is backed by plate glass.

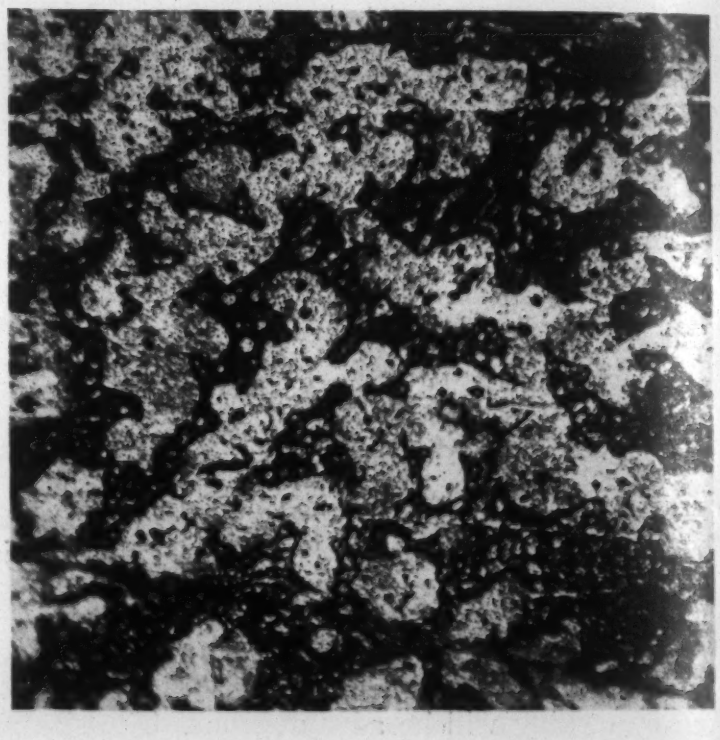
Papers of various degrees of fineness may be used but it was found that 1/0 and 3/0 paper were usually sufficient. A new paper about thirty times the area of the surface for solid specimens and eight times the diameter for tube specimens, should be used for each specimen. The paper should be scraped with a sharp straight edge to remove bumps or foreign particles and lubricated with an abundant supply of gasoline or a solution of paraffin in kerosene.

Grinding should continue on each paper with occasional addition of lubricant, until the emery is worn smooth and a bright surface on the lead free from prominent scratches is obtained. That will usually take about 5 to 7 min. on each paper. The specimen should be pressed firmly against the paper in grinding. It is then wiped free of gasoline or, if another lubricant was used, cleaned with gasoline and is suitable for etching as later described. Surfaces so prepared should etch free from scratch marks and will usually show sufficient detail for examination at any magnification normally used for lead. If, after etching, it appears that the preparation of the sample should be continued, an additional grinding of 4 to 6 min. in the above manner on Fischer brand 4/0 emery paper may be helpful.

Polishing

Polishing with standard equipment as recommended by Villella[2] is done after the surface of the specimen has been carefully ground smooth, and finished on a well worn 3/0 emery paper. Polishing is done wet on clean broadcloth smeared with an abundant supply of soap. A water suspension of the finest levigated alumina is used for abrasive. When a black smudge appears, polishing should be continued very carefully until it disappears and the surface is again bright.

Scratches left after the above polishing often are visible after etching but they can be removed by polishing by hand on a clean silk velvet or Selvyt cloth well soaked with soap and alumina. Additional polishing on the velvet pad is then alternated with etching operations as explained later but the pad must be maintained in a well soaked, slippery condition so that the final polishing can be carried out with sufficient rapidity to give a perfectly flat surface.

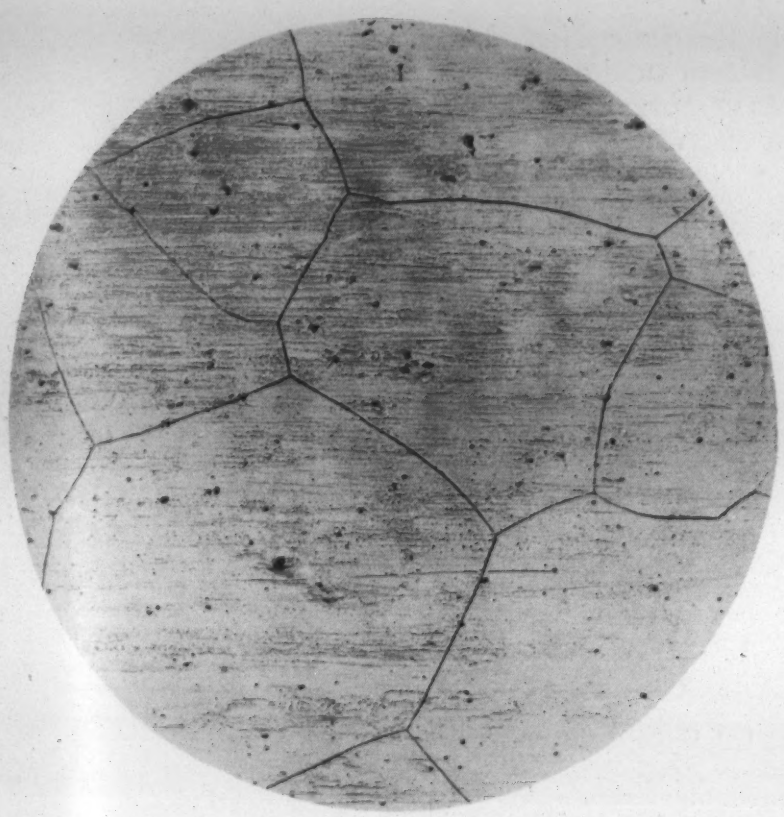


Wiping Solder (33% Sn, 0.50% Sb) in Cable Sheath Joint. Etched partially with Reagent No. 3 and finished by swabbing with 5 per cent nitric acid alcohol solution. Magnification, 350 diameters

Large Grain in Side of Lead Cable Sheath after Expanding 10 Per Cent, Showing Typical Deformation in Such Grains. Magnification, 15 diameters. Material is commercially pure lead containing 0.13 per cent Bi. Etched with Reagent No. 2A.

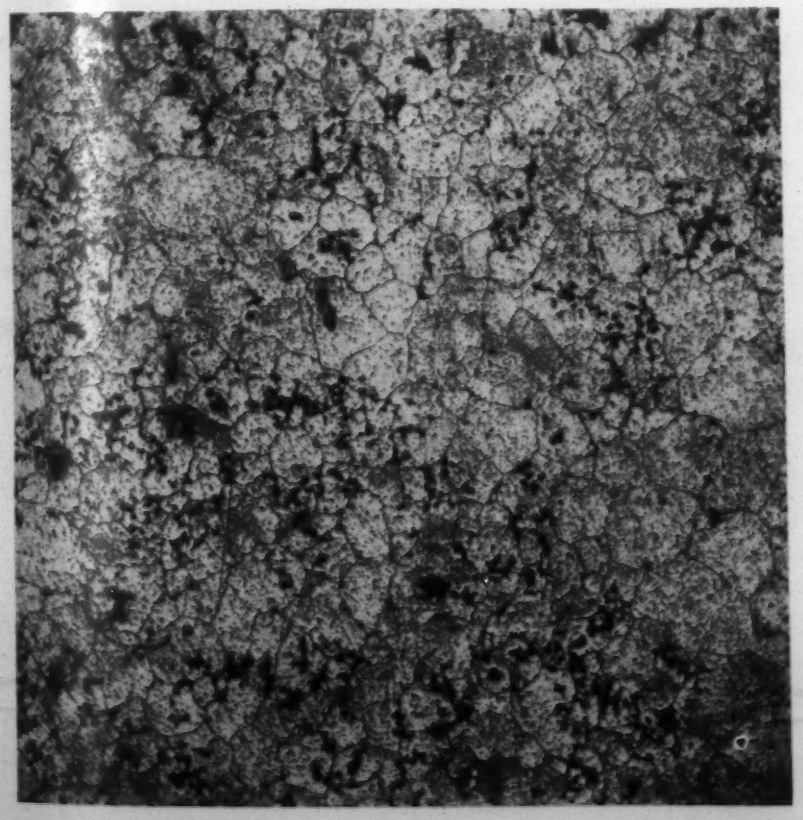
Etching

ETCHING of lead is not wholly independent of the method of preparation used as it seems that each authority has developed an etching reagent and procedure particularly suitable to his method of prepara-



A 1 per cent Antimony Cable Sheath after Heat Treatment at 238 deg. C. and quenching. Etched with Reagent No. 3 Magnification, 200 diameters.

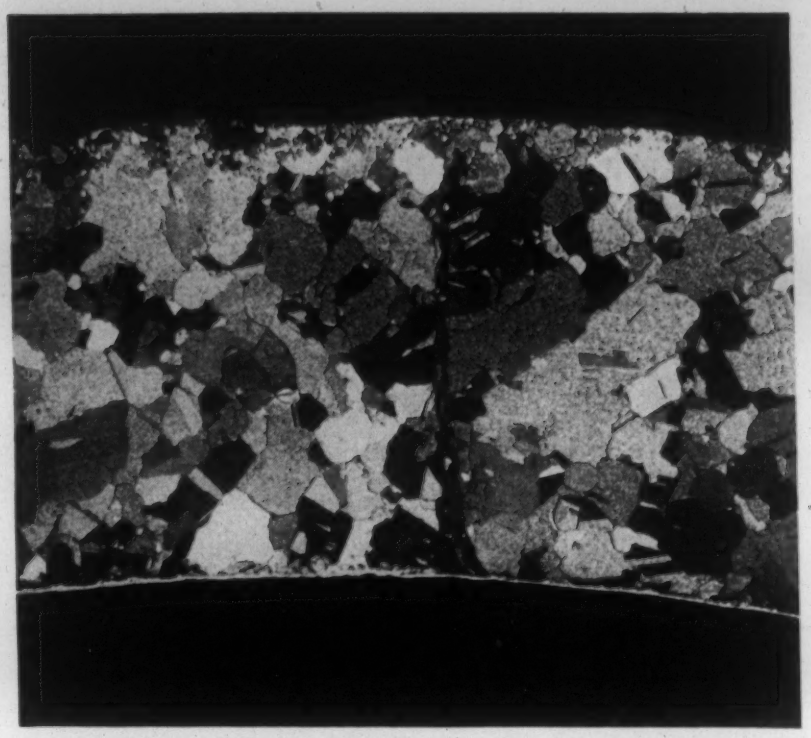
tion. In general, however, the reagents that are used for removing thick layers of worked metal will work universally, but others may present difficulties. Etch-



Structure of Alkali Hardened Lead Base Anti-Friction Metal (Satco). Etched with Reagent No. 1, Half Strength. Magnification, 75 Diameters.

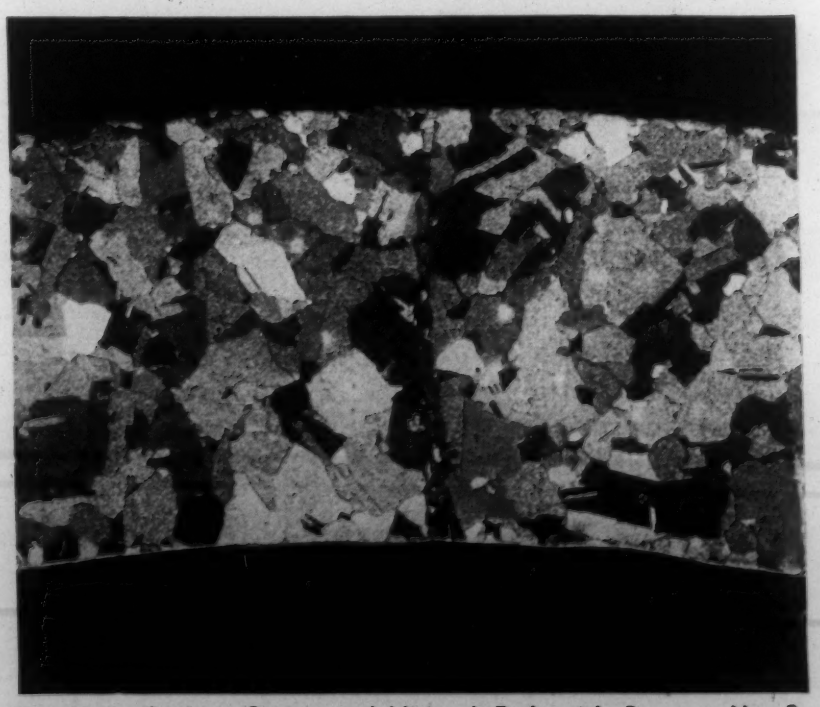
ing of lead alloys is more selective as to reagents and may require experimentation when specific information is lacking.

Proper drying of the surface after etching to preserve its clear cut bright appearance is very important.



(1) Machined and Etched with Reagent No. 2A. Magnification, 15 diameters.

(2) Same Specimen Ground on 4/0 Emery Paper and Fully Etched with Reagent No. 1. Magnification, 15 diameters.



(3) Above Surface Given an Additional Etch with Reagent No. 2. Magnification, 15 diameters.

Example of Three Stages of Preparation. Specimen shows a weld in a cable sheath of common desilverized lead, (Pb 99.85%, Bi 0.07%, Cu none)

This will be found more difficult after etching with some reagents than with others. Also some compositions of lead are more susceptible to tarnish than others. A warm humid atmosphere presents extreme difficulty and may require the use of an alkali protective film[3] or require the examination to be done while the specimen remains submerged in water.

In general, however, if a specimen is rinsed thoroughly by dipping in distilled water which is at, or just below, room temperature, the excess wiped from the sides, and the surface placed gently upon a piece of clean dry blotting paper for about 5 sec., it will dry relatively bright and uniform in appearance.

Table of Etching Reagents for Lead and Lead Alloys

No. Composition	Method	Remarks
1.[8]—Ammonium molybdate solution such as used for the quantitative determination of phosphorus. (See note below.)	Alternate swabbing and washing in running water. Formation of excessive deep brown color on surface should be prevented.	1.—Very rapid and especially suitable for removing thick layers of worked metal. Tends to pit around structural irregularities and emphasize them, if used excessively. Leaves brilliant finish difficult to photograph. Has been used on various kinds of lead, lead-tellurium alloys, lead-bismuth alloys, B.N.F. ternary alloys No. 2 and No. 3, lead-zinc alloys, alkali-metal-treated babbits and most other lead base alloys except those containing antimony. When used on alloys its action can be slowed by diluting 1 to 1 with water.
2.[5]— 3 parts glacial acetic acid, 4 parts conc. nitric acid, 16 parts water.	Use freshly prepared solution at 40 to 42 deg. C. Specimen immersed in solution 4 to 30 min., the time depending on the depth of worked metal on the prepared surface. Clean with wet cotton in running water.	2.—Produces excellent finish for photographing at magnifications of 0 to 50 diameters, but is slow in action. Has been used on various kinds of lead, lead-tin alloys up to 2½% tin, lead-bismuth alloys up to 3% bismuth, lead-tellurium alloys, B.N.F. ternary alloys No. 2 and No. 3 and many other alloys containing small amounts of other metals except antimony.
2A.—(Combination of Nos. 1 and 2.)	Prepared surface swabbed with Reagent No. 1 until structure is clearly visible; then immersed in Reagent No. 2 for approximately 6 min. Clean by swabbing in running water.	2A.—Combined advantages of Nos. 1 and 2, leaving surface that is more flat and smooth than obtained by Reagent No. 2 alone.
3.[4]—3 parts glacial acetic acid, 1 part 9% hydrogen peroxide.	Etch 10 to 30 min., the time depending on the depth of worked metal on the prepared surface. Clean with quick dip in concentrated nitric acid, if necessary.	3.—Commonly used on microtomed surfaces where the layer of worked metal is comparatively thin, but not limited to such. When used for deep etching, bumpy and rough surface may result. Has been used on lead, lead-calcium alloys, lead-tin alloys, lead-antimony alloys, and others, but essentially for lead-antimony alloys up to 2% antimony.[7] Proportions may be varied to suit state of "aging" of antimony alloys. (See discussion of paragraphs on Reagents and Their Applications.)
3A.[1, 3]—3 parts glacial acetic acid, 1 part 30% hydrogen peroxide.	Same as No. 3 except reduce time to 6 to 15 min.	3A.—Same as No. 3 except more rapid.
4.[2]—1 part glacial acetic acid, 1 part conc. nitric acid, 4 parts glycerol.	Use freshly prepared solution at 80 deg. C. Alternate 10 to 15 sec. etches with re-polishing until desired result is obtained. (See paragraph in text on "Polishing.")	4.—Commonly used in conjunction with standard polishing equipment. Has been used on most lead alloys and to some extent on lead. Prolonged etching will leave pitted and rough surface.
5.[5]—60% solution of perchloric acid.	For electrolytic etching. Specimen is cathode with a platinum anode.	5.—Recommended for antimony alloys above 2% antimony[7] but also suitable for lead, low tin and other alloys when only a light etch is required. Prolonged etching will leave a rough surface.
6.—5 to 10% solution of silver nitrate.	Alternate swabbing, washing, and cleaning with wet cotton.	6.—Sometimes used for anti-friction metals and other alloys. Was formerly used for lead, solder and other alloys, but is now displaced by newer reagents.
7.[6]—Nitric acid, conc. or diluted with from 3 to 9 parts of water.	Alternate dipping in conc. acid and washing. Acid may be diluted with from 3 to 9 parts of water and 10 to 90 min. etches used.	7.—Usually leaves rough and dull surface. Used for lead.
8.—Potassium dichromate, 2 to 5% solution.	Use by swabbing.	8.—Sometimes used for solders and other alloys not too high in lead.

Note: The ammonium molybdate solution is prepared as follows: Place in a beaker 100 g. of 85% molybdic acid, mix it thoroughly with 240 cc. of distilled water, add 140 cc. of NH_4OH (sp. gr. 0.90), filter, and add 60 cc. of HNO_3 (sp. gr. 1.42). This solution, when cold, is added to a cold dilute nitric acid which is prepared by adding 400 cc. of HNO_3 (sp. gr. 1.42) to 960 cc. of distilled water.

Reagents and Their Application

The Table shows a tabulation of etching reagents in common use along with methods of use and pertinent remarks on each.

Reagents Nos. 1, 2, and 2A were originally developed for use on ground or cut surfaces where a comparatively thick layer of worked metal had to be removed.

Reagent No. 1 is very rapid and over-etches surfaces if used excessively, which emphasizes structural irregularities and leaves a surface more suitable for visual examination than for photographic work.

Reagents 2 and 2A leave a finish that is comparatively easy to photograph at magnifications of 0 to 50 diameters. Reagent 2A produces the smoothest surface and is quite rapid. These are the reagents commonly used in examining the various kinds of lead cable sheath as described in the remarks given in the Table.

Reagents Nos. 3 and 3A are commonly used on microtomed surfaces where the layer of worked metal is comparatively thin but are not limited to such. However, when used for deep etching, they tend to leave bumps in the surface. They are essentially used for antimony alloys of 0 to 2 per cent antimony and for lead-calcium alloys. When used for antimony alloys, the proportions in the reagent are sometimes varied to fit the state of "aging" of the alloy.[3] Stained surfaces can be cleaned with concentrated sodium hydroxide solution or with the reagent in different proportions.

For structural detail in calcium alloys,[3] an additional treatment, wherein the specimen is transferred directly from the etching bath into a 2 per cent solution of acetic acid in alcohol and exposed to the air until the desired amount of staining takes place, is recommended. An alternate method is used wherein the surface is given a nitric acid dip subsequent to the etch. These

alloys should have the reagent removed by an alcohol rinse before the water in order to reduce the tendency to tarnish while drying.

Reagent No. 4 is used in conjunction with standard polishing equipment by a series of alternate etching and polishing operations until the desired clearness of structure is obtained.

Etching periods are from 10 to 15 seconds, and polishing is done on the silk velvet pad previously mentioned. Prolonged etching with this reagent will pit and roughen the surface. It has been used for the common grades of lead and for lead-antimony, lead-calcium, lead-tellurium and low tin alloys.

Reagent 5 is suitable for electrolytic etching of lead, lead-antimony alloys, especially those above 2 per cent, and for low tin alloys when only a light etch is required. Prolonged etching produces a rough surface.

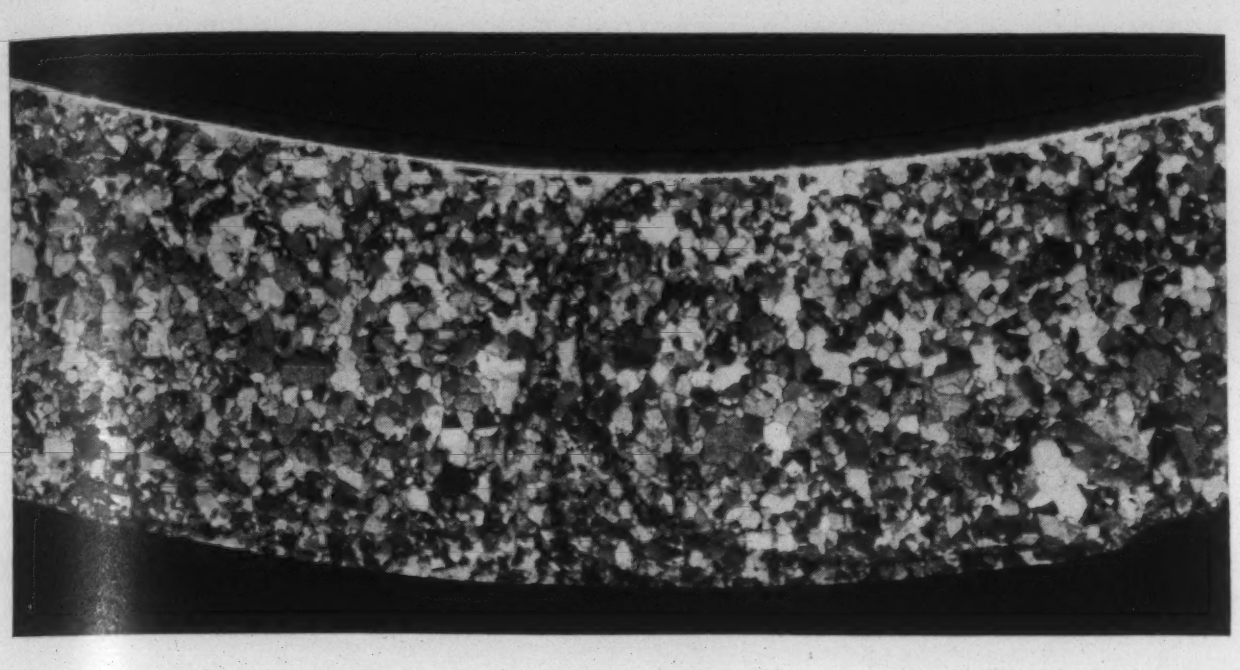
Reagent 6 is sometimes used for anti-friction metals. It was formerly used for lead, solder and for alloys, but has generally been displaced by the newer reagents.

Reagent 7 has been used in a number of laboratories as a means of rapidly etching the specimens. When used concentrated as a dip alternated with frequent washing, it is apt to overetch the surface. It may also be used diluted with 3 to 9 parts of water by immersing the specimen in the reagent for slow etching. Care must be exercised in the use of this material, otherwise the resulting surface is likely to be dull and rough.

Reagent 8 is sometimes used on solders and for alloys, but is not recommended for material having a high lead content.

In General

These notes on the preparation of lead and lead alloys for microscopic examination were assembled with the idea of bringing the methods up to date and in order to include such changes as have been made in the past few years. It was felt that these notes would assist other laboratory workers in their study of these metals and that the accompanying illustrations would emphasize some of the possibilities in this field. We believe that a careful study of the illustrations together with the accompanying text will confirm our recommendations.



Weld in a 1 Per Cent Tin Alloy Cable Sheath. Etched with Reagent No. 2. Magnification, 10 diameters.

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[7] R. S. Dean, L. Zickrick and F. C. Nix, "The Lead-Antimony System and Hardening of Lead Alloys," *Trans.* Am. Inst. Mining and Met. Eng., 1926, Vol. 73, p. 505.

[8] Brinkley Jones, "Notes on the Preparation of Lead and Lead Alloys for Micro Examination." Inst. of Metals (British) 1933, Vol. 52, No. 2, p. 73.

Nitriding Characteristics of Cr-Mo-V Steels

To the Editor: At the end of the article entitled "Nitriding Characteristics of Cr-Mo-V Steels" by Jerome Strauss and W. E. Mahin, published in the March issue [METALS AND ALLOYS], there appeared a note which is not entirely correct in that the patent referred to does not disclose steels of the carbon content described in this article. The work recorded represents an original development in the laboratories of the Vanadium Corporation of America, although other work on Cr-Mo-C steels for nitriding has been independently carried on by other investigators.

The Nitralloy Corporation controls patent applications based on the results of some of this other work. These are in addition to the patent covering the nitriding process and patents covering aluminum-containing steels for use with this process.

JEROME STRAUSS
W. E. MAHIN
A. C. DUFAULT

April 12, 1935

Erratum: At the bottom of the first column of the article, "Heat Treatment and Paint Drying by Inductive Heat," on page 85 of the April issue of METALS & ALLOYS, the words "less than 50 deg. F." should read "less than 5 deg. F." The automatic control takes care of 50 deg. F. changes in the desired temperature, depending on the chemical composition of the steel.

Fluidity Test Equipment for White Iron

By ENRIQUE TOUCEDA*

THE PATTERN EQUIPMENT used by the writer and a number of the plants of the Malleable Iron Research Institute for fluidity tests appears to have advantages over some of the patterns previously described by other workers.

The entire assemblage consists of an accurately machined aluminum flask made up in four sections, as shown in the accompanying illustration, one of the sections consisting of a frame in which the pattern proper is suspended. When the various sections are superimposed on each other, the overall inside dimensions are 18 in. x 6 in. x 7⅜ in. deep. When the mold is made up and pattern withdrawn, the flask is 18 in. x 6 in. x 6 in. deep, because "C" will be the drag and "D" the cope as will be described further on.

The match "A" is set on the floor and between it and section "C" is inserted pattern frame "B." "C" is then rammed with sand and struck off. A floor board is then placed on "C" and this assembly reversed. "A" is then discarded and "D" substituted for it. "D" is then rammed up with the sprue core in position. The core is then removed; "D" is lifted up to allow for the removal of the pattern frame and is then replaced on "C" and its top made level in all directions for reasons previously explained. It is seen therefore that the final flask is made up of drag "A" and cope "D."

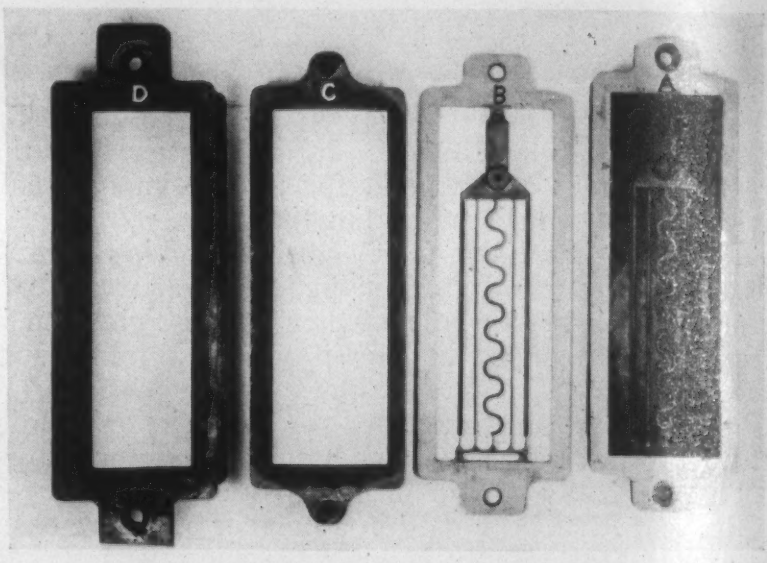
The sections marked "A", "B", "C", and "D" are respectively 1 in., ⅜ in., 2 in. and 4 in. deep. The pattern proper, shown suspended in its frame marked "B", consists of five fluidity test bars. The cross section of the one on the extreme left is diamond shaped, the two diameters being each ¼ in. The bar on the extreme right is circular in section and ¼ in. in diameter. The bar in the center is of circular section, 3/16 in. in diameter, and is not straight but wavy as shown in the illustration. The two intermediate bars are each ⅛ in. in diameter. All of the test bars are 1 ft. long measured from end to end. The equipment is so designed that when the top surface of the cope is leveled longitudinally and cross-wise, a line through the neutral axis of each test bar will be level to the top surface of the flask. This is to make certain that when the metal is poured in the mold, gravity will play no part in the running of the fluidity bars.

A pouring gate and basin leading to it, to serve as a reservoir for the molten metal to flow at constant head into the mold, is formed by a core that registers with the pouring-sprue-seat shown in "B", that is the molten metal is poured into the basin; overflows into the mold void at a constant head uninfluenced by the height of the ladle over the basin, while, inasmuch as the pattern has been made level in all directions, the running of the test bars is not affected by gravity.

The only variables in the test are the temperature and moisture of the sand and the temperature of the molten metal. In practice, it is customary to fill the mold always at a certain time after the heat has been tapped. In works practice care is taken to use a hot ladle, the temperature of the metal at the furnace spout being ascertained by an optical pyrometer. Sand conditions are kept as uniform as is commercially possible in the foundry.

The pattern is simply used for control work, that is, at 2850 deg. F. or thereabouts, the two extreme bars run full and the two adjacent ones somewhat more than three-quarters of their length. (No attention is paid to the wavy bar, so for this purpose it might as well be omitted.)

So long as the conditions referred to obtains, the iron is fluid enough to pour any patterns on the floor. Actually the purpose of the pattern is to prevent the molders from claiming that their loss through misruns is due to a lack of fluidity of the iron rather than to carelessness on their part. It has been used more for this purpose than with any other object in view. It is obvious that, if the apparatus is to be used for delicate work much greater care than is called for in foundry control work would have to be exercised in connection with all of the variables.



Equipment Used in Making the Fluidity Tests

The equipment shown here was made by the Frazer & Jones Co., Syracuse, N. Y., and has proved very practicable and serviceable for the purpose intended. The cross sections of the two outside bars are of different shape and area, both bars being straight; the middle bar is not straight; its section is circular; it is different in area from the two outside bars, and is designed to furnish a crude idea of the effect of friction. The intermediate bars are circular in cross section and furnish a very excellent idea as to how thin a section can be cast from the metal at the temperature at which it is being poured.

The writer experimented for some time with the spiral test bar suggested by Japanese workers at the University of Kyoto, but it did not prove as satisfactory for the purpose as the design described in this article, which it is believed yields information of a more diversified character.

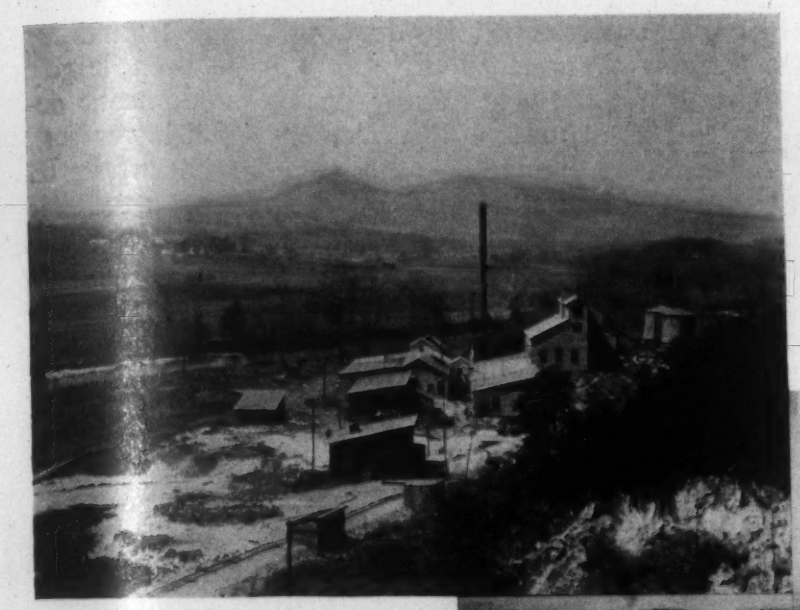
* Consulting Engineer, Albany, N. Y.

TITANIUM—

Its Supply and Economics*

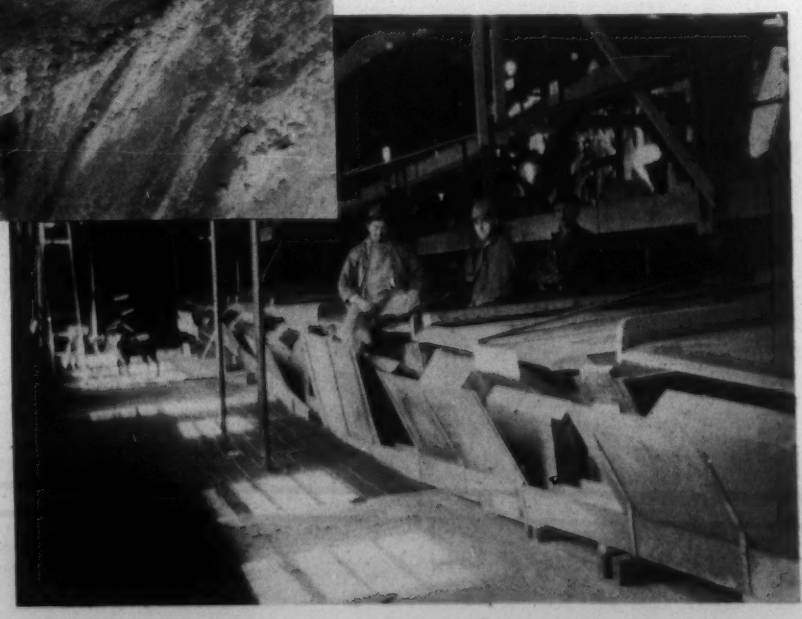
By PAUL M. TYLER†

TITANIUM IS A CONSTITUENT of almost all common rocks and is contained in greater or smaller amount in a great variety of minerals. Ilmenite and rutile, however, are the only minerals that have been mined at all extensively as titanium ores, and commercial deposits of these minerals are relatively few.



Mill Buildings of Rutile Mine of the American Rutile Corp., Roseland, Va.

Open Cut (Left) Rutile Mine of the American Rutile Corp., Roseland, Va.



Concentrating Tables in Ore Dressing Plant of the American Rutile Corp., Roseland, Va.

Sources of World Supply

Rutile, the natural dioxide, is an accessory mineral in most metamorphic rocks and in many pegmatites, but it occurs somewhat more abundantly in basic igneous rocks. Ilmenite likewise is typically associated with basic rather than acid or highly silicious rocks (such as granite), and this is true, too, of titanium-bearing magnetites which occur as very large bodies in various parts of the world.

An enormous supply of titanium is locked up in the deposits of titaniferous iron ores and low-grade ilmenites, some containing up to 30 per cent TiO_2, but attempts to work ores of this character hitherto have generally failed to be financially successful except where the titanium content is sufficiently low (say under 3%) to use them economically in the iron blast furnace, in which case of course the titanium content is dissipated. Processes exist for enriching these ores by smelting them into pig iron and recovering a high-titanium slag that can be re-smelted or utilized to make pigments, but so long as abundant supplies of high-grade ilmenite are forthcoming at a really low price, the urge to put them into practical use has been lacking.

Bauxites contain titanium dioxide in amounts ranging from under 1 per cent up to 10 per cent or more, the average from several commercial sources being around 2 or 3 per cent. Even before 1900 efforts were made by Howard Spence at Manchester, England, to find an outlet for the titanium residues from alum works employing bauxite, and the red muds from the Bayer process used for refining bauxite for aluminum manufacture are enriched so as to contain 10 to 15 per cent TiO_2. Many hundreds of thousands of tons of this material have accumulated at East St. Louis. This red mud can be worked up into ferric alum leaving a silicious residue from which titanium sulphate can be extracted, but the yield of TiO_2 is of the order of only 6 per cent of the ferric alum output, and production of titanium or its compounds from this source is accordingly limited by the possibility of dis-

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† Chief Engineer, Rare Metals and Nonmetals Division, U. S. Bureau of Mines, Washington, D. C.

posing of the ferric alum, which has rather a restricted sale for water purification.

Domestic Deposits of Titanium Ores

The principal domestic deposits of commercial titanium ores are in Virginia, where ilmenite and rutile both occur in varying proportions in nelsonite intrusions over a wide area. Norway was for many years the only producer of rutile for international trade until the United States began producing in 1903, but in Norway the rutile and ilmenite are mined in entirely different localities; they do not occur together there as they do in Virginia. Canada, Australia, and more recently Brazil have produced a little rutile. The world production of this high-priced mineral, however, is still very small. Before the World War it rose gradually from about 100 to about 200 tons annually, of which the United States supplied about two-thirds. Probably there has never been a year when as much as 1,000 tons of rutile was produced, and certainly never a year when any such quantity was consumed.

Outside of the United States, the principal deposits of ilmenite are in Canada, at St. Urbain and Ivry, Quebec; in Norway, along the coast between Ekersund and Soggendal; in Australia, notably at Olary, South Australia; in Madagascar; and in various African localities. Except in Norway and the United States, lode deposits have been worked only to a limited extent or not at all. To an apparently increasing extent the world's titanium needs are supplied by concentrating beach-sand deposits, many of which carry zircon and occasionally rutile and monazite. By far the most important of such deposits is that of Travancore, British India, although deposits of generally similar character have been developed in Brazil, Senegal, the Gold Coast, Australia, and Florida and California.

World Output of Ilmenite

The rapid increase in world production of ilmenite, as shown in Table I, is due almost wholly to the fast-

Table I.—World Production of Ilmenite by Countries, in Metric Tons, 1920 to 1933.

Year	India (Travancore)	Norway	Senegal	Brazil [1]	Canada	Other [2]	Total
1920	.....	3,378	.....	.....	871	500	5,000
1921	.....	2,567	.....	.....	.....	250	3,000
1922	406	3,300	.....	113	478	5,000	9,000
1923	711	2,620	.....	290	63	6,500	10,000
1924	651	3,472	352	210	1,277	5,000	11,000
1925	333	4,162	181	1,500	3,609	5,500	15,000
1926	4,304	4,200	5,748	1,498	181	5,000	21,000
1927	18,095	5,733	5,199	1,307	1,841	5,000	37,000
1928	25,713	7,948	2,110	2,102	2,036	2,500	42,000
1929	24,050	7,923	7,240 [1]	6,361	2,493	500	48,500
1930	29,238	7,630	5,322 [1]	80	374	2,000	45,000
1931	36,746	5,000	1,074	.....	1,369	1,000	45,000
1932	50,856	13,481	.....	35	.....	3,000	67,000
1933	44,078	23,213	310 [1]	([3])	.....	3,000	70,000

[1] Exports.
[2] Ineludes estimates for United States, Portugal, Australia, Egypt, Sierra Leone, Madagascar, etc.
[3] Data not available.

growing popularity of titanium pigments. The dominant position of British India is apparent. The Travancore sands were worked for monazite, beginning in 1911, but, with the decline in the gas-mantle industry and expansion of titanium requirements, the monazite has become a minor product. Other countries have not shared in the increased demand for ilmenite, except perhaps Norway, which staged a sharp comeback in 1933. Contractual relationships play a large part in the growing importance of British India, but production costs and freight rates also play a part. Moreover, the Indian product is considerably higher in titanium dioxide content than that furnished elsewhere, averaging recently 54 per cent compared with 53 per cent for Brazil, 50 per cent for Portugal, 48 per cent for Senegal, 43 per cent for Norway, and generally under 25 per cent for Canada. Concentrates produced in the United States have ranged from 35 to 52 per cent in TiO_2 content.

Production only since 1920 is shown in Table I, but this is the period of real growth of the industry. Until 1903, Norway's small rutile output was virtually the only commercial production of titanium ores aside from a few hundred pounds of rutile gathered from the surface of fields in Chester County, Pa. By 1909, the Virginia mines, which came into operation in 1903, had surpassed Norway, and a few scattered shipments were made from Canada and other countries, but it was 1910 before the world output of titanium ores exceeded 3,000 tons, and the advent of the World War, although it stimulated certain minor products, tended to delay rather than to hasten the expansion in aggregate demand.

United States, a Large Importer

The United States has become the largest consumer of titanium ores, both for making pigments and for alloys. Its ilmenite requirements have been largely imported, not because of any dearth of domestic deposits but as a matter of convenience and lower cost. Production of pigments has tended to concentrate on the North Atlantic seaboard, which is more accessible to overseas shipments than to rail delivery from Virginia deposits. Travancore has been the sole foreign source of ilmenite imports recently, but beach deposits in Senegal and Brazil formerly shared in this trade to a substantial extent. Rutile has also been imported but only in insignificant quantities in most years, as domestic output tends to outstrip demand.

Disregarding stocks, the imports of ilmenite, as shown in Table II, afford a rough index of the im-

Table II.—Imports and Prices of Ilmenite, 1929-34.

	Imports for Consumption			
		Reported value [1]		
Year	Quantity, long tons	Total	Average	American price [2]
1929	22,386	$104,887	$4.68	$9.50 to $11.00
1930	22,297	150,466	6.75	9.50 to 12.00
1931	29,857	144,951	4.85	10.00 to 12.00
1932	33,491	231,652	6.92	10.00 to 12.00
1933	38,610	196,211	5.08	10.00 to 12.00
1934	71,710	356,190	4.97	10.00 to 12.00

[1] Nominally f.o.b. foreign mines.
[2] F.o.b. Atlantic seaboard, 45 to 52% TiO_2.

portance of the titanium pigment industry. Unfortunately, however, the official statistics before about 1929 fail to record the total quantity received from overseas. In 1928, for example, the importations classified as ilmenite amounted to only 15,379 gross tons, whereas a study of the customhouse records revealed additional imports of some 5,000 tons of material received from ilmenite-producing countries and valued at around $4 a ton but entered by the importer, and consequently classified in the official statistics, as "sand, other than glass sand." During earlier years, ilmenite derived from beach sands appears to have been included in the import figures for sand and other items that, like ilmenite itself, were exempt from duty and consequently subjected to merely superficial examination by customs inspectors.

Now that the import trade has become better organized the official statistics are probably a more accurate index of this growing business, although, of course, they tell nothing as to the magnitude of the titanium-alloy business. Domestic production figures for titanium ores as well as for titanium alloys have been lack-

ing during the last few years because they cannot be published without disclosing the operations of the one or two leading producers, but considerable further expansion is needed before domestic mining will contribute more than about 10 per cent of the large and growing titanium ore consumption in the United States.

The average reported value of the imports of ilmenite varies somewhat from year to year but not in any apparent relation to sterling or rupee exchange. Recent values, around $5 a gross ton, f.o.b. Travancore, check fairly well with the trade journal quotations of $10 to $12 for 45 to 52 per cent ore, f.o.b. Atlantic seaboard; ocean freight and other charges doubtless amount to about $5 a ton. These quotations are nevertheless more or less nominal. They have not been changed for several years, and the business is mainly contractual, anyway. Prices for rutile are likewise nominal and have remained unchanged at 10c. a lb. for several years. Recent imports from Brazil have been reported as valued at under 2.5c. a lb. Freight in this case is naturally a less significant item whereas warehousing and selling expense bulk larger.

Economic Considerations

A price of, say, $12 a gross ton for ilmenite containing 50 per cent TiO_2 is equivalent to about 40c. per long ton unit of elemental titanium. Even manganese ores cost considerably more than titanium ores per unit of metal (manganese) content, delivered at American ferromanganese furnaces, duty paid. Chrome ores cost half again as much per unit of metal (chromium) content. The raw material for making titanium alloys accordingly appears to be remarkably cheap as well as abundant, cheaper in fact than the ores of any of the steel-making alloy elements except silicon and aluminum. In the form of the cheapest alloy, ferrocarbon-titanium, titanium costs over 40c. a lb., almost ten times as much as manganese in the form of standard 80 per cent ferromanganese and four times as much as chromium additions. It cannot compete with high-grade silvery iron or bessemer ferrosilicon as a deoxidizer because these sell for much less than one-third the price, and even 50 per cent ferrosilicon furnishes several times as much oxygen-consuming equivalent per dollar.

It follows that titanium is altogether too expensive for present use as a general deoxidizer and can be employed economically only for a final scavenging, after ferromanganese or ferrosilicon additions have done most of the work. Even for killing steel in the ingot mold, aluminum costs less. For alloying purposes, price per pound and combining weight are frequently less important than better performance of the finished steel; nevertheless they have to be considered. The use of the nickel and chromium steels undoubtedly would have expanded much less rapidly if these alloying agents had been as costly as tungsten or vanadium. Molybdenum costs around twice as much as titanium, but sales resistance from this angle has been met effectively by the slogan "a little does a lot"; only minute amounts of molybdenum are needed to produce definitely beneficial results.

Naturally the market for a ferroalloy, as for any commodity subjected to technical sales analysis, is a matter not only of dollars but of common sense, but without laboring the point further the present writer desires to emphasize the fact that the wide spread between the cost of raw material and that of the finished product in the case of titanium alloys offered to the steel industry tends to restrict the field of use. The mere fact that a century elapsed before titanium alloys were placed on the market indicates that the process of manufacture is both difficult and being difficult, it is consequently costly.

One of the virtues of the element is its chemical activity, the fact that it has a greater avidity for oxygen than any other element commercially employed (in metallic condition) in steelmaking except aluminum and vanadium, but it is recognized that this is one of the reasons the alloys are hard to make. However, enough progress has now been made by physical metallurgists in the mapping out of uses to stimulate efforts by process metallurgists to cheapen manufacturing methods. It is always a question as to which comes first, lower prices or increased consumption, but experience in the case of aluminum, magnesium, molybdenum, and sundry other successfully merchandized technical products seems to demonstrate that the two go hand in hand. In any event, the recent progress of titanium in metallurgy foreshadows developments of interest both to metallurgists and to business men.

(Continued from page 124)

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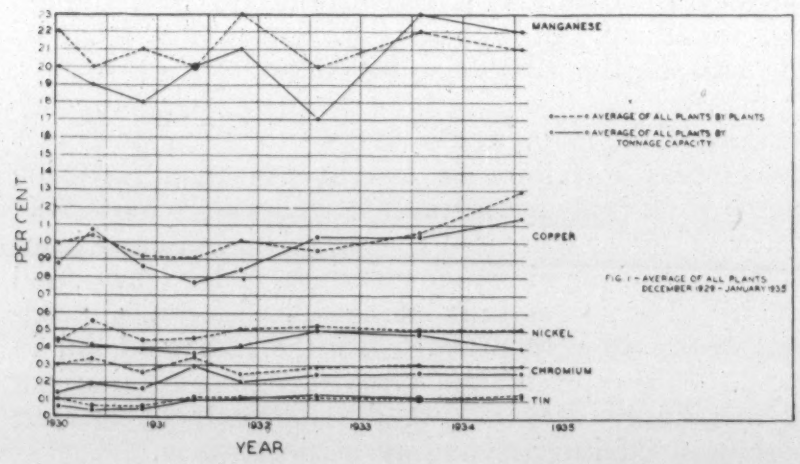
Residual Metals in Open-Hearth Steel

By JOHN D. SULLIVAN*

OWING TO THE USE IN basic open-hearth furnace charges of alloy steel scrap, tin plate clippings, detinned, galvanized, and other coated scrap, and of non-ferrous metals or parts that cannot be separated from scrap economically, basic open-hearth steel has been gradually increasing in copper, chromium, nickel, and tin. Most of the foreign metals introduced into the basic open-hearth charge through



Average of All Plants, December, 1929, to January, 1935

scrap are partly or wholly recovered in the steel. Some plants that are dependent on the use of large ratios of scrap, high in some of these metals, have produced ingots of exceptionally high content of some of these metals that have come from the scrap used. The presence of residual metals that come from scrap has been a source of much concern to steel plant operators.

Improved qualities of the steel have sometimes been thought to result from the presence of these adventitious metals. On the other hand, difficulties in rolling the steel or in working the finished products have cast suspicion on some of these elements. It is evident that the residual metal content will increase in open-hearth steel as increasing amounts of alloyed and coated steel are made and returned as scrap. Whether they are beneficial or harmful, it is desirable to know their amounts and the trend of any changes in those amounts. In order to appraise the amount of these metals normally present in ordinary steel and the rate at which they are increasing, the matter has been studied for several years.

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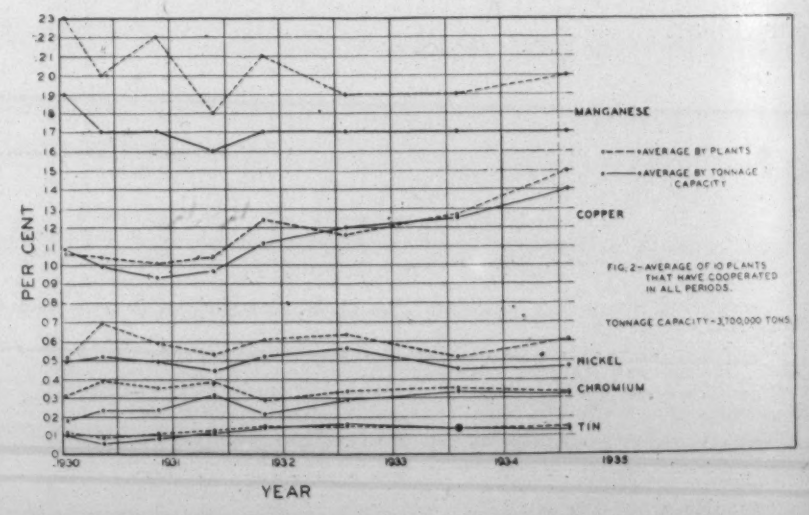
Previous Records

In previous articles[1], residual metals in open-hearth steel were discussed and analyses were presented from various steel companies in the United States and Canada. As was stated in former articles, samples are taken from representative heats before alloy additions are made. The impurities in the samples, therefore, represent those coming from the scrap, pig iron, and ore. Most of the residual metals, except manganese, enter the melt through the scrap, although appreciable quantities of chromium and copper may come from the pig iron and ore. The percentage and kind of scrap used in the charge influence the amounts of residual metals found in the melt before alloy additions are made.

The samples represent the melt-down composition of the charge before alloy additions are made. Different plants take the samples at different stages between the time of melt-down and the time for addition of ferro-alloys. These differences in sampling procedure will



Average of Ten Plants That Have Cooperated in All Periods

affect the figures for oxidizable elements and for residual manganese to some degree, but on the whole the data indicate the composition of the "plain carbon steel" base used in the various plants before adjust-

[1] Clyde E. Williams and John D. Sullivan. "Residual Metals in Open-Hearth Steel." METALS & ALLOYS, Vol. 3, 1932, page 240.
Clyde E. Williams and John D. Sullivan. "Residual Metals in Open-Hearth Steel." METALS & ALLOYS, Vol. 4, 1933, page 151.
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ment of composition by alloying elements. At the end of the month composite samples are made and sent to Battelle Memorial Institute. Here, annual composites are made for analysis. The collection of samples and making of analyses go on from year to year. This report brings the results up to date.

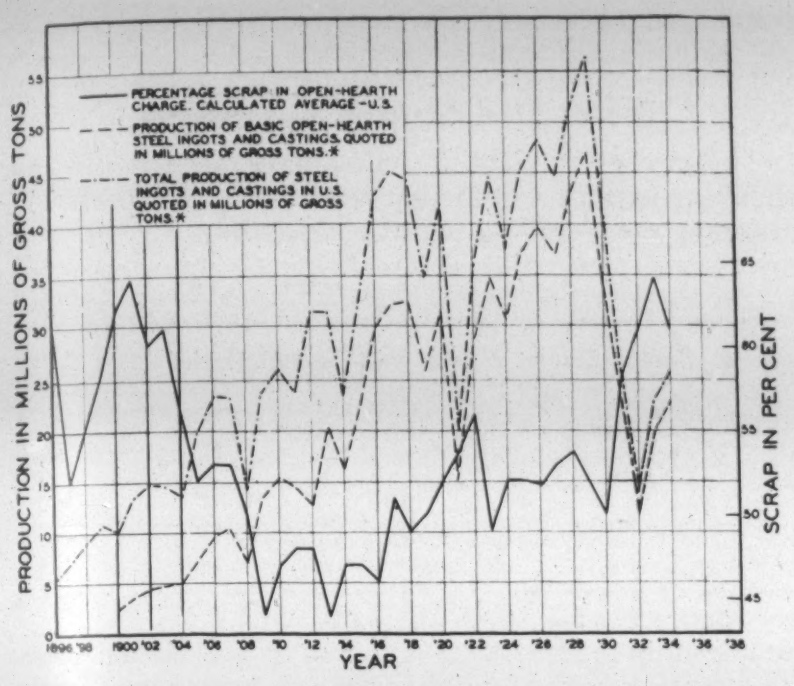
PERCENTAGE SCRAP IN OPEN-HEARTH CHARGE. CALCULATED AVERAGE—U.S.
PRODUCTION OF BASIC OPEN-HEARTH STEEL INGOTS AND CASTINGS. QUOTED IN MILLIONS OF GROSS TONS.*
TOTAL PRODUCTION OF STEEL INGOTS AND CASTINGS IN U.S. QUOTED IN MILLIONS OF GROSS TONS.*
PRODUCTION IN MILLIONS OF GROSS TONS
SCRAP IN PER CENT
YEAR

Fig. 3.—Relation between Amount of Scrap Used in Basic Open-Hearth and Production of Basic Open-Hearth and Total Steel (*1934 Estimated).

Nickel, copper, tin, chromium and manganese determinations were made. Manganese is not a residual metal in the same sense as the others because it is purposely added to the charge, principally in the pig

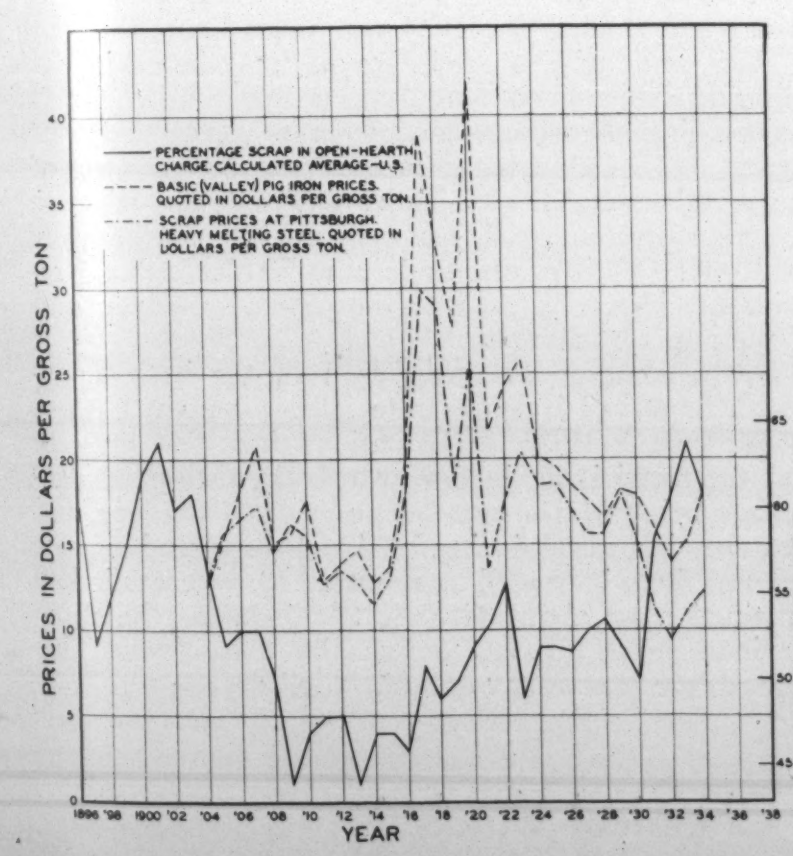
PERCENTAGE SCRAP IN OPEN-HEARTH CHARGE CALCULATED AVERAGE—U.S.
BASIC (VALLEY) PIG IRON PRICES QUOTED IN DOLLARS PER GROSS TON.
SCRAP PRICES AT PITTSBURGH. HEAVY MELTING STEEL. QUOTED IN DOLLARS PER GROSS TON.
PRICES IN DOLLARS PER GROSS TON
SCRAP IN PER CENT
YEAR

Fig. 4.—Relation between Amount of Scrap Used in Basic Open-Hearth and Prices of Basic Pig Iron and Scrap.

iron, so as to finish the heat with a predetermined residual manganese content.

Since the first paper of this series showed that the amounts of arsenic, lead, vanadium, molybdenum and zinc present as residual metals were 0.001 per cent or less, analyses were not made for these elements since that time.

Table I. Residual Metals In Open-Hearth Steel

MARCH, 1931, TO JANUARY, 1935, INCLUSIVE

Plant No.	1931 Mar.-July	1931-32 Aug.-Jan.	1932-33 Feb.-Jan.	1933-34 Feb.-Jan.	1934-35 Feb.-Jan.
			Nickel—Per Cent		
A	0.039	0.063	0.109	0.074	0.115
B	0.021	0.024	....	0.013	0.016
C	0.043	0.054	0.054	0.033	0.040
D	0.039	0.035	....	0.070	0.091
E	0.089	0.071	0.055	0.050	0.074
F	0.032	0.072	0.057	0.057	0.057
G	0.041	0.037	0.037	0.029	0.039
H	0.071	0.060	0.062	0.052	0.051
I	0.008	0.030	0.027	0.023	0.023
J	0.021	0.038	0.041	0.161	0.047
K	0.019	0.031	0.049	0.036	0.027
L	0.053	0.039	0.048	0.030	0.044
M	0.039	0.034	0.042	0.062	0.038
N	0.041	0.040	0.043	0.017	0.013
O	0.063	0.083	0.068	0.077	0.086
P	0.082	0.107	0.087	0.079	0.075
Q	0.057	0.050	0.047	0.047	0.039
R	0.063	0.044	0.060	0.051	0.049
			Copper—Per Cent		
A	0.025	0.045	0.051	0.061	0.058
B	0.022	0.044	....	0.059	0.056
C	0.097	0.215	0.218	0.150	0.196
D	0.104	0.053	....	0.173	0.218
E	0.268	0.296	0.193	0.234	0.318
F	0.106	0.080	0.080	0.114	0.118
G	0.030	0.015	0.015	0.040	0.049
H	0.075	0.077	0.097	0.101	0.126
I	0.059	0.074	0.069	0.077	0.077
J	0.049	0.062	0.050	0.041	0.091
K	0.076	0.084	0.120	0.104	0.124
L	0.075	0.077	0.083	0.094	0.075
M	0.117	0.085	0.098	0.099	0.083
N	0.065	0.113	0.085	0.115	0.093
O	0.202	0.215	0.182	0.269	0.281
P	0.088	0.138	0.122	0.098	0.150
Q	0.122	0.114	0.116	0.129	0.135
R	0.040	0.032	0.061	0.082	0.078
			Tin—Per Cent		
A	0.004	0.003	0.004	0.004	0.007
B	0.007	0.008	....	0.007	0.005
C	0.017	0.025	0.034	0.016	0.006
D	0.011	0.008	....	0.019	0.024
E	0.035	0.041	0.021	0.028	0.041
F	0.014	0.013	0.014	0.013	0.012
G	Nil	0.003	0.005	0.004	0.005
H	0.011	0.017	0.012	0.014	0.014
I	0.008	0.006	0.005	0.009	0.008
J	0.003	0.006	0.006	0.004	0.011
K	0.008	0.012	0.014	0.011	0.011
L	0.007	0.006	0.013	0.014	0.010
M	0.008	0.009	0.010	0.008	0.006
N	0.008	0.008	0.011	0.010	0.018
O	0.020	0.017	0.018	0.025	0.025
P	0.009	0.015	0.017	0.011	0.015
Q	0.021	0.022	0.018	0.023	0.023
R	0.005	0.004	0.008	0.008	0.008
			Manganese—Per Cent		
A	0.22	0.24	0.23	0.21	0.25
B	0.23	0.23	....	0.39	0.39
C	0.11	0.11	0.10	0.12	0.10
D	0.21	0.24	....	0.27	0.18
E	0.11	0.24	0.12	0.12	0.13
F	0.15	0.16	0.14	0.16	0.16
G	0.35	0.46	0.42	0.38	0.40
H	0.12	0.11	0.10	0.12	0.12
I	0.10	0.08	0.06	0.08	0.10
J	0.27	0.48	0.22	0.24	0.25
K	0.12	0.13	0.14	0.14	0.14
L	0.26	0.24	0.27	0.24	0.27
M	0.25	0.24	0.20	0.19	0.22
N	0.16	0.16	0.14	0.17	0.16
O	0.19	0.18	0.18	0.19	0.14
P	0.24	0.24	0.23	0.25	0.25
Q	0.25	0.23	0.21	0.21	0.20
R	0.26	0.31	0.30	0.31	0.27
			Chromium—Per Cent		
A	0.048	0.031	0.040	0.040	0.038
B	0.024	0.019	....	0.008	0.007
C	0.020	0.019	0.028	0.029	0.029
D	0.030	0.019	....	0.041	0.039
E	0.052	0.036	0.033	0.038	0.036
F	0.031	0.026	0.029	0.030	0.030
G	0.044	0.038	0.040	0.038	0.035
H	0.029	0.030	0.028	0.030	0.033
I	0.012	0.012	0.013	0.012	0.012
J	0.021	0.021	0.021	0.025	0.031
K	0.025	0.011	0.025	0.035	0.032
L	0.033	0.022	0.027	0.032	0.030
M	0.023	0.006	0.010	0.022	0.020
N	0.034	0.031	0.034	0.027	0.029
O	0.049	0.036	0.041	0.041	0.037
P	0.049	0.030	0.038	0.034	0.034
Q	0.049	0.046	0.045	0.039	0.037
R	0.021	0.021	0.023	0.029	0.031

Residual Metals in Steel

In Table I results are reported from March, 1931, to January, 1935, inclusive. A normal tonnage capacity of 8,600,000 tons is represented by the 18 plants cooperating in the current period.

Fig. 1 shows graphically the average percentage of residual metals from all plants cooperating from December, 1929, to January, 1935, inclusive. Results are given for the arithmetic mean of all plants and also for the weighted average based on normal annual tonnage capacity. In Fig. 2 results are given from the ten plants that have cooperated in all periods since this investigation started. In the figures the year is plotted as the middle of the period represented. Analyses reported in Figs. 1 and 2 were made at the Pittsburgh Station of the U. S. Bureau of Mines until March. 1931, and at Battelle Memorial Institute since that time.

The average of all plants, by tonnage capacity, shows a marked increase over the previous period for copper, a marked decrease for nickel, a drop of one point in manganese, with tin and chromium remaining constant. The average, by plants, shows nickel remaining constant, a drop of one point in manganese, a slight drop in chromium, a slight increase in tin, and an appreciable increase in copper.

The average, by tonnage capacity, of the ten plants that have cooperated in all eight periods shows manganese remaining constant, a slight decrease in chromium and tin, a slight increase in nickel, and a marked increase in copper. In the same ten plants the average, by plants, shows an increase of one point in manganese, a slight decrease in chromium, a slight increase in tin, and appreciable increases in both nickel and copper.

The most pronounced change during the past year was the marked increase in copper.

An examination of the data in Table I shows that in the case of some individual companies marked changes occurred since the previous period in the amount of various residual metals. Data are given in Table II showing the number of companies in which the residual metal content increased, decreased or remained constant. Manganese is not included in this tabulation since it is purposely added to the charge. Since a small change in composition may be within the limits of analytical error, values are also given in which any change of $\pm$ 0.005 per cent for nickel or copper, $\pm$ 0.004 per cent for chromium, and $\pm$ 0.002 per cent for tin is taken as indicating no change. Actually, the precision of analytical methods is much better than the allowed tolerance. The fact that the chromium content changed but little from the previous period in the individual plants is worthv of note.

Table II. Changes In Residual Metal Content In Individual Companies During Current Period from Seventh Period

	Based on Actual Analyses											
	Nickel			Copper			Tin			Chromium		
	Up	Down	Same	Up	Down	Same	Up	Down	Same	Up	Down	Same
All 18 Plants	8	8	2	11	6	1	7	6	5	4	10	4
10 Plants That Have Cooperated In All 8 Periods	6	3	1	8	2	0	4	3	3	1	6	3
	Allowing Tolerance for Analytical Errors											
All 18 Plants	7	4	7	10	3	5	6	2	10	1	0	17
10 Plants That Have Cooperated In All 8 Periods	6	1	3	7	1	2	3	2	5	0	0	10

Use of Steel Scrap in Open-Hearth

The curves in Figs. 3 and 4 have been plotted to show the variation in the amount of steel scrap used in different years and to permit comparison of this with prices and production rates. Figures for scrap consumption up to 1934 were obtained by calculation from the statements of basic pig iron production and basic open-hearth steel production contained in the annual statistical reports of the American Iron and Steel Institute and in Mineral Industry. For 1934 calculations were based on the estimated production for the first six months of the year. For this period data were obtained for basic pig iron production from a statistical bulletin of the American Iron and Steel Institute, and for basic steel ingots and castings from *The Iron Age*. The production of open-hearth and total steel ingots and casting for 1934 was taken from the Jan. 3, 1935, issue of *The Iron Age* and may be subject to slight changes when final reports are prepared. In determining the percentage of scrap used, it was assumed that (1) an ingot recovery of 88 per cent of the metal charged was made, (2) metallic addition agents equivalent to 1 per cent of the charge were used, and (3) iron ore containing 50 per cent of recoverable iron was used to the extent of 5 per cent of the pig iron charged.

The percentage of scrap used in the basic open-hearth increased steadilv from 50 per cent in 1930 to 64 per cent in 1933. Calculations for 1934 indicate that the trend is again downward, the estimated percentage being 61 per cent. The price of pig iron and scrap has increased during 1934 and the spread in price between them increased to about $5.70, whereas it had remained from about $4.00 to $4.50 during the three previous years. Even though the price spread increased, the percentage of scrap used decreased.

Appendix—Methods of Chemical Analysis

NUMEROUS requests have been received from cooperating plants and from readers of previous articles for the methods of analysis used in determining small amounts of these impurities in steel. The methods used for determining nickel, copper, tin, and chromium are therefore given. In most instances no originality of method is claimed, although certain innovations have been made in standard methods to fit the requirements of the special problem. The methods of analysis used were chosen after long study of, and experimentation with, possible methods. They were chosen on the basis of accuracy and not speed. The bismuthate method for manganese is used, but as this is so well known and as the percentage present is not so small as to require any unusual precautions, it is not given below.

NICKEL.—Weigh a 3-gram sample into a 250-c.c. beaker. Add 30-c.c. 1:1 HCl. When action has nearly ceased, add 5-c.c. concentrated HNO_3 to oxidize the iron. Boil until all of the iron is in solution and then take to dryness and bake ½ hr. to dehydrate the silica. Add 10-c.c. HCl and heat until salts are in solution. Dilute to about 100-c.c. Add 15 grams of citric or tartaric acid and filter. The citric or tartaric acid corresponds to 5 grams per gram of sample. Catch the filtrate in a 400-c.c. beaker, dilute to about 250-c.c., and heat to about 60 deg. C. Do not dilute to a

greater volume because separation of dimethylglyoxime may take place later if the volume is too large. Add ammonia to make the solution slightly alkaline. This can be tested with litmus paper and by the odor of ammonia. The solution must be stirred thoroughly and the gas in the space above the solution blown off before the odor test is of any value. Add acetic (or hydrochloric) acid until the solution is just acidic. While stirring the solution vigorously, add 10-c.c. of dimethylglyoxime solution (1 gram dissolved in 100-c.c. ethyl alcohol). Add ammonia to make the solution slightly alkaline. Stir the solution vigorously. At this point, if the degree of alkalinity is correct, the red precipitate will commence to form. If it does not form, add a few drops of acetic (or hydrochloric) acid or ammonia and continue changing slightly the alkaline or acidic nature of the solution until the precipitate forms. The temperature should be about 60 deg. C. Let cool to room temperature and stand over night. Filter, using a Gooch crucible, the weight of which is *known* to be constant. Wash with cold water and dry for 1 hr. at 110 deg. C. Weigh. The weight of precipitate $\times$ 0.2031 = weight of nickel.

COPPER.—Weigh a 5-gram sample into a 600-c.c. beaker. Cover with a watch glass. Add 100-c.c. 1:10 H_2SO_4 and when violent action ceases put on a hot plate and digest until no further reaction takes place. The volume of solution at this point should be brought to about 400-c.c. Heat to boiling. Carefully add about 15-c.c. saturated hypo solution in 3 portions of 5-c.c. each to precipitate the soluble copper as CuS. Keep the beaker covered with a watch glass. Boil until the solution is nearly clear, add 5-c.c. more hypo solution, and boil until clear. Finally test with H_2S water to be sure all copper is precipitated. Filter through a fast paper and wash the precipitate at least 10 times with hot water. Put the precipitate and filter paper into a Battersea crucible and ignite at a low temperature. Care must be taken not to heat the crucible too rapidly or too high; otherwise CuS will fuse to the walls and bottom. Preferably the crucible should be put into a cold muffle and heated to about 800 to 850 deg. C., or ignited in the flame of a Meeker burner. The ignited residue is brushed into a 250-c.c. beaker and 2 to 3-c.c. concentrated HNO_3 and about ¼ gram potassium chlorate are added. (However, if the ignited residue shows a red color of iron oxide, it should be dissolved in HCl and the copper re-precipitated with hypo, and proceed as above.) Take to dryness and bake for about 1 min. Add 1 to 2 c.c. concentrated HNO_3 and take just to dryness, but do not bake. The copper nitrate should not be decomposed to oxide. If the crystallized salt becomes black, indicating the presence of copper oxide, add 1-c.c. HNO_3 and repeat. Add about 25 c.c. boiling water and digest. Add, drop by drop, 6 per cent NaOH solution until a permanent black precipitate forms. Add 10-c.c. glacial acetic acid. When the solution becomes clear, remove from the hot plate and cool to room temperature. Add 3 grams potassium iodide and titrate with standard sodium thiosulphate, using starch as indicator. Prepare the standard sodium thiosulphate solution so that 1 c.c. is equivalent to 0.001 gram copper. The solution may be made by dissolving 3.95 grams $Na_2S_2O_3 \cdot 5H_2O$ and 1 gram NaOH in water and diluting to 1 liter. Standardize against pure copper.

TIN.—Weight a 10-gram sample into an 800-c.c. beaker and add 225 c.c. 2:7 HNO_3. Cover with a watch glass and warm gently until vigorous action ceases. Boil for 5 to 10 min. after the sample is completely decomposed. Add 10 to 15-c.c. of 2½ per cent $KMnO_4$ solution and boil for 5 min. Oxides of manganese should separate. If not, add 5 c.c. more $KMnO_4$ solution and again boil. Repeat, if necessary. Add a saturated SO_2 solution carefully to put the oxides of manganese back in solution. Boil for at least 15 min. to expel excess SO_2. Cool to room temperature and dilute to 500 c.c. Pass in a rapid stream of H_2S for at least 30 min. Preferably use tank H_2S to insure a rapid stream. Let settle at least 2 hr. and preferably overnight. Filter, and wash with a solution slightly acidified with H_2SO_4, containing about 3 per cent of $(NH_4)_2SO_4$ and saturated with H_2S. Transfer the paper and precipitate to a 500-c.c. Erlenmeyer flask and add about 15 c.c. concentrated H_2SO_4 and 25 c.c. concentrated HNO_3. Heat slowly until fuming ceases and then evaporate to fumes of SO_3. The globule of sulphur should be yellow. If not, add 5 c.c. of concentrated HNO_3 and continue heating and fuming. Repeat the addition of HNO_3, if necessary. Cool. Dilute to 100 c.c. Heat to boiling and filter to remove sulphur. Wash with water. Add to the filtrate 15 c.c. of a ferric chloride solution made by dissolving 0.6 gram anhydrous $FeCl_3$ (or equivalent of hydrated salt) in 2 to 3 c.c. concentrated HCl and a little water and diluting to 100 c.c. Heat to boiling and add concentrated NH_4OH until the solution is neutral to methyl red and then about 2 c.c. in excess. Filter and wash four times with 2 per cent NH_4OH and finally three times with H_2O. Dissolve the precipitate by passing a hot mixture of 80 c.c. concentrated HCl and 100 c.c. H_2O through the paper and catching the filtrate in a 500-c.c. Erlenmeyer flask. Dilute to 350 c.c. and add 5 c.c. of a solution made by dissolving 0.8 gram $SbCl_3$ in 25 c.c. HCl and diluting to 100 c.c. Add 10 grams of test lead, preferably about 20 to 30 mesh. Insert a 3-hole rubber stopper in the mouth of the Erlenmeyer flask. Through one of the holes insert a glass tube approximately 5 mm. in diameter and about 2 to 2½ ft. long. The end of the tube should extend about an inch below the stopper. This acts as an air condenser. Through the second hole insert an inlet tube which dips beneath the surface of the solution. Carbon dioxide is led into the apparatus from a tank through this inlet tube and escapes through the air condenser. The third hole is plugged with a small stopper or glass rod. Start passing in CO_2 and heat the solution to incipient boiling and hold at this temperature for 30 min. after the iron color has disappeared. Gentle boiling may be employed but the upper portion of the air condenser should not become warm. Cool to 10 deg. C. while continuing the passage of CO_2. Remove the stopper from the third hole and add 5 c.c. of starch solution and then insert the tip of a burette through the hole and titrate with iodine solution to the first permanent shade of blue. CO_2 should be passed through the solution during titration. Run a blank on reagents and correct for the volume of iodine required in the blank. The iodine solution is made by dissolving 0.13 gram iodine and 1 gram KI in a little water and diluting to 1 liter. Standardize the iodine against freshly prepared sodium arsenite solution.

CHROMIUM.—Weigh a 10-gram sample into a 400-c.c. beaker and add 110 c.c. of 10 per cent by volume H_2SO_4. Heat to boiling and boil until reaction is complete. Dilute to about 250 c.c. and heat to boiling. Add an 8 per cent solution of $NaHCO_3$ (80 grams per liter) from a burette until a permanent precipitate appears and then add 4 to 10 c.c. in excess. Avoid too large an excess. Boil for 1 min., let settle, and filter through a rapid 11-cm. filter paper. Quickly wash beaker and precipitate 2 or 3 times with hot water. The filtrate will become cloudy but this need not worry the analyst, as this is due to oxidation and hydrolysis. Discard the filtrate. Ignite the residue in a 20-c.c. iron crucible. Fuse with 12 to 15 grams Na_2O_2. Cool and dissolve by immersion in 100 c.c. of cold water in a 400-c.c. beaker. Remove the crucible, add 1 gram Na_2O_2, and boil 5 to 10 min., or allow to stand longer on a moderately heated hot plate or steam bath. Transfer to a centrifuge cup and centrifuge for about 10 to 15 min. Decant the solution from the residue on the bottom of the cup. Add a little cold 2 per cent solution of NaOH containing about 1 per cent of Na_2SO_4. Stir the residue and re-centrifuge. Decant the supernatant liquid and repeat the washing and centrifuging operations. If a centrifuge is not available, the solution may be filtered through an asbestos pad and the beaker and funnel washed with a cold 2 per cent solution of NaOH containing 1 per cent of Na_2SO_4. One may even use a filter paper that has first been washed with 5 per cent NaOH solution to remove the yellow color. Boil solution to a volume of about 75 c.c. and filter through an asbestos pad. Transfer solution to a Nessler tube and compare the color with a standard solution of K_2CrO_4 containing approximately the same concentration of chromium and alkali. This is made by fusing the same weight of Na_2O_2 as was used on the sample in an iron crucible and carrying through all manipulation in the same manner.

To prepare the standard solution dissolve 1.867 grams K_2CrO_4 in water and dilute to 1000 c.c. Each c.c. contains 0.0005 gram chromium.

Surface Tension of Molten Lead Alloys

To the Editor: Referring to H. Vance White's article in your March issue on The Surface Tension of Molten Lead Alloys Under Oxidising Conditions, the writer has made a number of observations parallel to those of Mr. White on the effect of very small amounts of impurities on the surface tension of melts made in air. These observations were made in connection with the use of zinc, aluminum, calcium, beryllium, silicon, magnesium and sodium as deoxidants in melts of lead alloys, high-tin bronzes, nickel-silver, etc.

In the writer's work, no attempt was made to measure surface tension exactly, but great differences in the sharpnesses of the castings were observed as a result of additions of as little as a few hundredths of one per cent, in some cases, of a deoxidant. Sodium lowers the surface tension not only of lead alloys, but also of bronze, silicon, silicon-tin and silicon-copper alloys. The other deoxidants mentioned almost invariably increase surface tension.

It is the writer's belief that the phenomena can be explained very simply. The deoxidants used all have greater free energies of oxidation than the metals of the melts with which they were used. The oxide films formed on the melts are therefore the pure, or nearly pure, oxides of the deoxidants. As the surface tension of the melt is largely due to that of the oxide film, it is to be expected that, where the surface tension of the oxide film is high, that of the melt would be correspondingly so.

It is noticeable that the oxides of all the deoxidants mentioned above (except sodium) are, at the temperatures of the respective melts, solids of low vapor pressure, which implies high surface tension. Sodium oxide, on the other hand, has a very high vapor pressure at the temperature of molten lead, and boils below the temperature of most of the melts in which it was tested. Its surface tension is therefore very low, and that of the melts in which it occurs is correspondingly lowered.

As to the anomalies observed by Mr. White in the cases of cadmium and potassium, cadmium oxide sublimes at about 1000 deg. C., whereas zinc oxide does not; and consequently a higher surface tension is to be expected in the case of the latter. Potassium oxide does not sublime whereas that of sodium does so very close to the melting point of lead. Therefore potassium oxide must have a higher surface tension than sodium oxide at that temperature. This is all in qualitative agreement with Mr. White's observations.

The low surface tension of lead-antimony alloys probably results from a low surface tension of antimony oxide, as indicated by its high volatility. The free energy of formation of antimony oxide is greater than that of lead oxide, so that the oxide film consists principally of the former in melts of these alloys.

As a corollary to the above reasoning, an impurity whose free energy of oxidation is lower than those of the principal constituents of the melt would have little effect on the surface tension of the latter under oxidising conditions, since its oxide would not appear in the film.

Formerly with
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LEO G. HALL,
Metallurgist.

Items of Interest

F. J. Tone Awarded the Acheson Medal

Frank J. Tone, president of The Carborundum Co., Niagara Falls, N. Y., was awarded the Edward Goodrich Acheson Medal by The Electrochemical Society at its annual Spring meeting in March. This is the second distinguished award to come to Mr. Tone in recent years, he having been the first recipient of the Jacob F. Schoelkopf Medal presented by the Western New York section of the American Chemical Society.

The Edward Goodrich Acheson medal was founded in August, 1928, by the late Dr. Acheson, the inventor of carborundum and long recognized as an outstanding figure in electrochemistry. The award is made every two years to "the person who shall have made a distinguished contribution to the advancement of any of the objects, purposes, or activities of the society and is the highest honor which can be paid by The Electrochemical Society.

Three distinguished men have previously received the Acheson award; Dr. Acheson himself in 1929, for his discovery of the processes of manufacturing carborundum and graphite; Dr. Edwin Northrup for his invention and development of the high frequency induction furnace in 1931; and in 1933, Dr. Colin G. Fink for a series of achievements in the field of electrochemistry processes for making ductile tungsten filaments and the electroplating of chromium.

The Acheson Award goes to Mr. Tone for his many and important contributions to the development and perfection of practical and commercial processes in the fields of electrochemistry, electrometallurgy and electrothermics, these contributions extending their benefits to the field of all useful arts. It will be formally bestowed on him at the fall meeting in Washington, Oct. 10 to 12.

J. H. Critchett New President Electrochemical Society

At the annual spring meeting of The Electrochemical Society, held in New Orleans, James H. Critchett, vice-president, Union Carbide & Carbon Research Laboratories, Inc., New York, was elected president for the ensuing year.

The fall meeting will be held in Washington, Oct. 10 to 12. Cincinnati has been selected as the location for the spring convention, April 23 to 25, 1936. The fall meeting next year is scheduled for Niagara Falls, Ontario, with a definite date not yet decided upon.

New President for R. W. Hunt Co.

The Robert W. Hunt Co., engineers, conducting a national and international engineering inspection, testing, and consultation service, with general offices in Chicago, has accepted the resignation of C. B. Nolte, the president who has accepted the presidency of Crane Co. James C. Ogden, formerly vice president, in charge of Robert W. Hunt Co., eastern and foreign activities at New York, will succeed Mr. Nolte as president. Mr. Ogden has been actively engaged with the organization for the past 35 years and in an executive capacity since 1908. He is a member of the American Society of Civil Engineers, the Engineers' Club of New York, the American Society for Testing Materials, various other engineering organizations and the Plainfield Country Club. Mr. Ogden will be assisted in the operation of the organization by F. M. Randlett, as vice president and general manager.

Testing Society's Annual Meeting

The thirty-eighth annual meeting of the American Society for Testing Materials will be held at the Book-Cadillac Hotel, Detroit, June 24 to 28. The Society's third exhibit of testing apparatus and related equipment will be a feature.

A technical program of commanding interest has been prepared. One session will deal with "The Place of Materials in Automobile Roads and Rides." Another will be devoted to five or six technical papers on "Spectrographic Analysis," sponsored by Committee E-2. A round table session on "Radiography and X-Ray Crystallography" will be another feature. The usual number of papers on ferrous and non-ferrous topics will be presented.

The Edgar Marburg Lecture will be delivered by Dr. L. B. Tuckerman, engineer-physicist, National Bureau of Standards.

Battelle Memorial Institute of scientific and industrial research, Columbus, Ohio, announces the appointment of **Dr. H. R. Nelson** as a member of the technical staff. At the Battelle laboratories Dr. Nelson will be in charge of a research project consisting of a study of the application of electron-diffraction methods to metallurgical problems. This new field of activity offers many possibilities of practical application.

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Read the Current Metallurgical Abstracts each month to keep posted on the world's Metallurgical Developments.

CLASSIFICATIONS

ORE CONCENTRATION (1)
- Crushing, Grinding & Plant Handling (1a)
- Gravity Concentration (1b)
- Flotation (1c)
- Magnetic Separation (1d)
- Amalgamation, Cyanidation & Leaching (1e)

ORE REDUCTION (2)
- Non-Ferrous (2a)
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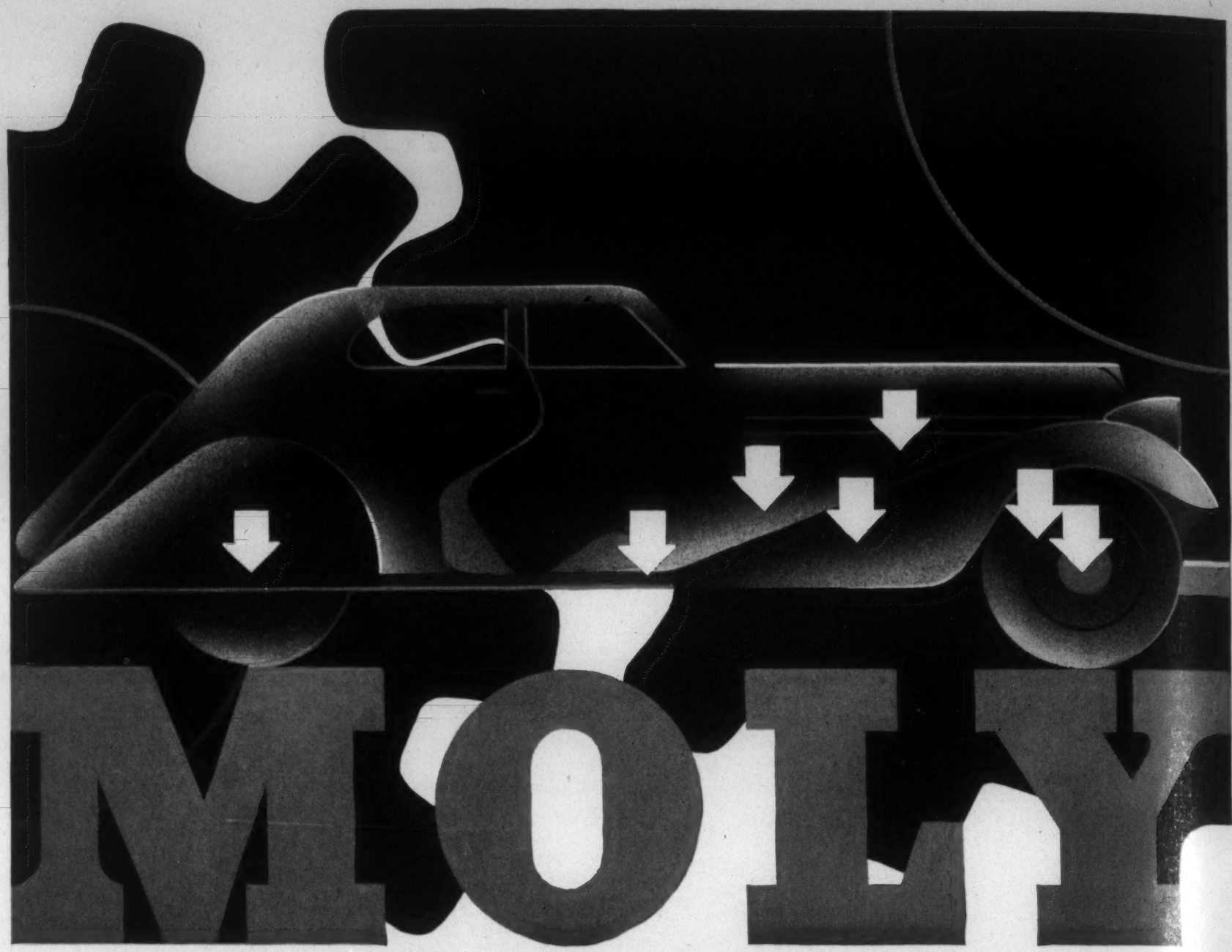

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CLIMAX Mo-lyb-den-um

1. ORE CONCENTRATION

JOHN ATTWOOD, SECTION EDITOR

Corduroy as a Gold Saver. M. W. VON BERNEWITZ. *Engineering & Mining Journal*, Vol. 136, Feb. 1935, pages 63-67. This early method of recovery is revived and applied on a steadily increasing scale by Cu producers in South Africa, Canada, and the U. S. A. WHB (1)

Gold-Silver-Copper-Zinc Ore from the Lynx Property at Oxford Lake, Northern Manitoba. *Canadian Department of Mines, Mines Branch Report*, No. 743, 1934, pages 67-70. An ore containing Au 0.40 oz., Ag 1.52 oz./ton, Cu 1.69% and Zn 4.46% could not be amalgamated or cyanided in the raw state. The Cu can not be separated from the Au and the Zn by flotation; 57% or more of the Au and 25% or more of the Zn always are found in the Cu concentrate. AHE (1)

Investigations of the Precious Metal and Vanadium Content in Samples of Mineralized Rock Submitted by Delta Mines Syndicate, Worthington, Ontario. *Canadian Department of Mines, Mines Branch Report*, No. 743, 1934, pages 107-110. The three samples contained only traces of V_2O_5 and Pt group metals and 0.003-0.007 oz. Au/ton. The precious metals were concentrated with Cu, Ni, and Fe sulphides in the flotation concentrates; and V was concentrated to a similar extent in the table concentrate (of the flotation tailing) with the oxides of Fe and Ti. AHE (1)

Gold Ore from the Columario Gold Mines, Ltd., Usk, British Columbia. *Canadian Department of Mines, Mines Branch Report*, No. 743, 1934, pages 132-135. An ore containing Au 1.44 oz., Ag 3.51 oz./ton, Cu 0.42%, Pb 0.02%, and As 0.01% was amalgamated, cyanided and floated. Cu causes high cyanide consumption. Removal of a small bulk of high-grade concentrate makes cyanidation of the flotation tailing possible. A recovery of 60.7% of the Au, 58% of the Ag and 90% of the Cu was obtained in a concentrate assaying 10% Cu, 20.6 oz. Au and 49 oz. Ag/ton. Ratio of concentrate was 23.2:1. Cyanidation of the tailing gave an overall Au recovery of 93%, and Ag 91.4%. Cyanide consumption was 1.95 lbs./ton of ore. AHE (1)

1a. Crushing, Grinding & Plant Handling

Sintering of Krivoi Rog Iron Cores. S. T. ROSTOVTZEV & S. M. MEYEROV. *Domez*, No. 11-12, 1934, pages 7-39. In Russian. Comprehensive investigation of sintering qualities of iron ores containing 59.8-68.3% Fe and 2-12% SiO_2. Laboratory experiments in a Greenawalt type apparatus were followed by plant experiments on a Dwight-Lloyd belt. All these ores can be sintered to retain 80-90% on a 5 mm. sieve. Moisture content of the mixture should be 6-8%, fuel content 5-7% of the weight of the ore. Much better results are obtained when there is added to the charge 15-20% of the material which has once passed the sintering process. Theoretical aspects of the question are fully presented based on the bibliography of 54 titles. (1a)

1c. Flotation

Simple Change in Flotation Cell Improves Both Concentrate and Tailing. ALFRED B. SABIN. *Engineering & Mining Journal*, Vol. 136, Feb. 1935, page 68. At the Yellow Aster mill, near Randsburg, Calif., it was found that the froth from the flotation cell tended strongly to concentrate in the launder and that by pulling the machine hard enough a froth was secured which was high grade in its upper layer and which could be made to overflow the side of the launder. Resulting tailings were lower than in any other way. A second launder caught the overflowing concentrate. Au recovery increased 20%. WHB (1c)

More Facts in the Flotation of Free Gold. L. H. LANGE. *Engineering & Mining Journal*, Vol. 136, Mar. 1935, pages 116-118. A series of tests was conducted on a siliceous free Au ore containing less than 1% of sulphide with the Au free to the extent that about 80% was recovered by amalgamation at 55%-200 mesh grinding. The heads of this ore averaged .55 oz. Au/ton. Results are summarized: (1) lime and soda ash produce a depressing effect on the flotation of free Au, (2) a H_2SO_4 circuit at 4:1 flotation density on an ore containing a small amount of sulphides, aids in the flotation of the free Au, but in pulp of higher densities a marked depressing effect results, (3) sodium sulphide acts as a depressant in the flotation of free Au, (5) sodium silicate has a slight depressing effect on the flotation of free Au, (6) pentasol xanthate, amyl xanthate, aerofloat No. 3, and a combination of pentaxanthate and a thiocarbanilide were the collectors that produced the best results on the ore used for this study, and (7) the flotation of free Au is best brought about in circuits of high pulp density, namely 2.5:1. WHB (1c)

Nickel-Copper Ore from the Gersdorffite Property, Near Worthington, Ontario. *Canadian Department of Mines, Mines Branch Report*, 743, 1934, pages 113-116. The ore assayed Ni 2.66%, Cu 1.28%, Co 0.16%, Au 0.05 oz., Ag 0.42 oz., and Pt group 0.494 oz./ton. Alteration of the Ni makes it difficult to obtain a bulk concentrate high in Ni. Best results (86% recovery) were obtained by using a distinctly alkaline pulp, increasing K xanthate and grinding to 90% —200 mesh. The concentrate from the best test contained 1.49 oz./ton of Pt group metals, largely Pd. AHE (1c)

Effects of Copper Sulphate in Oxidized Gold Flotation. ALFRED B. SABIN. *Mining Journal*, Arizona, Vol. 18, Feb. 15, 1935, page 5. The elimination of $CuSO_4$ in floating oxidized ores of Yellow Aster Mill, Randsburg, Cal., with Aerofloat No. 25 and 301 xanthate provided simpler, more efficient and more easily controlled operation. A saving of reagents to the extent of 2½c/shilling ton of ore also resulted. Elimination of the conditioner was a saving in power and feed equipment for other uses. WB (1c)

Silver-Lead Ore from Queensboro, Ontario. *Canadian Department of Mines, Mines Branch Report* No. 743, 1934, pages 117-118. The ore assayed Pb 2.15, Cu 0.61, Zn 0.17%, Au 0.20 oz. and Ag 6.58 oz./ton. Flotation recovers 90% of the Au, 87% of the Ag and 90% of the Pb. AHE (1c)

Selective Flotation at Ridder Works. S. P. ALEXANDROV. *Non-Ferrous Metals*, Vol. 9, No. 1, 1935, pages 59-93. In Russian. Pb and Zn ores had to be concentrated. The present practice gives quite inferior results. Every step of the flotation operations is investigated in detail. (1c)

1d. Magnetic Separation

New Magnetic Separator for Concentration of Ores. C. W. DAVIS. *Steel*, Vol. 95, Dec. 24, 1934, pages 37-38. Magnetic separator developed by the author and R. S. Dean uses a.c. of 60-120 cycles to produce a relatively low field strength (about ½ that of the coercive force of the mineral being treated) and effects rapid separation of the magnetized particles by causing them to jump away from the waste material. Belt type and drum type of a.-c. magnetic separator seem especially suitable for concentration of ores. Tabulate some representative results obtained with various ores. These indicate that a-c. separation has distinct possibilities for the future enrichment of low-grade ores and the purification of high-grade products. MS (1d)

Magnetic Properties and Orientation of Ferromagnetic Particles. C. W. DAVIS. *Physics*, Vol. 6, Mar. 1935, pages 96-99. Tests made on natural and artificial magnetic oxides of Fe to determine the effect of orientation on magnetic properties of the particles. Results of preliminary tests by direct methods show definitely that alignment of particles in a magnetic field increases their magnetization up to saturation and augments their remanence, but that coercive force is not noticeably affected. WB (1d)

1e. Amalgamation, Cyanidation & Leaching

Gold Ore from the Tamarac Mine, Ymir, British Columbia. *Canadian Department of Mines, Mines Branch Report* No. 743, 1934, pages 3-4. The ore consisted of sulphides of Fe and As with silicious gangue and assayed Au 0.38 oz., Ag 0.09 oz./ton and As 10.36%. Cyanidation of —150 mesh ore gave 76% Au recovery. Flotation gives no appreciable concentration; tailings contain 0.10 oz. Au. Amalgamation gave no recovery. AHE (1e)

Gold Ore from the Hants Gold Mines, Ltd., Central Rawdon, Nova Scotia. *Canadian Department of Mines, Mines Branch Report*, No. 743, 1934, pages 37-40. Amalgamation gave a recovery of 86-90% of the Au; cyanidation of the tails raised recovery to 99.2%, the same as straight cyanidation. Flotation tails contain 0.04 oz. Au/ton. A flow sheet is suggested. AHE (1e)

Arsenic Gold Ore from the Blomfield Property, Marmora Township, Hastings County, Ontario. *Canadian Department of Mines, Mines Branch Report*, No. 743, 1934, pages 111-112. An ore assaying Au 0.855 oz./ton, As 11.6% and Cu trace was amalgamated and cyanided at various sizes. Recovery by amalgamation was 83.04%; cyanidation dissolved 86.55-97.66% of the Au (increased with fineness) with 24 hrs. agitation and 95.32-98.83% with 48 hrs. treatment. Recovery is better with a minimum of CaO. AHE (1e)

Experimental Tests on Three Samples of Gold Ore from Cedar Island, Shoal Lake, Lake of the Woods District. C. S. PARSONS, A. K. ANDERSON, J. D. JOHNSTON & W. S. JENKINS. *Canadian Department of Mines, Mines Branch Report* 736, 1934, pages 156-165. The ore contains Ag 0.35-0.62 oz. and Au 1.435-5.07 oz./ton. A Au trap recovers 40-50% of the Au. Amalgamation recovers 65-70%, concentration of tails and barrel amalgamation of the concentrate raises recovery approximately 10%. Flotation yields only fair recovery. Cyanidation gives 96% extraction. AHE (1e)

Gold Ore from Canadian Minerals, Limited, Morton Lake, Manitoba. *Canadian Department of Mines, Mines Branch Report*, No. 743, 1934, pages 30-33. From 77 to 88% of the Au can be recovered by amalgamation of the ore containing Au 0.57 oz., Ag 0.06 oz./ton, Zn 0.20% and Cu 0.08%. Cyanidation of —200 mesh ore extracts 98% of the Au. Amalgamation followed by flotation recovers 94.9%. Flotation alone gives low recoveries. A flow sheet is suggested. AHE (1e)

2. ORE REDUCTION

A. H. EMERY, SECTION EDITOR

2a. Non-Ferrous

Preparation of Pure Gallium. JAMES I. HOFFMAN. *Bureau of Standards Journal of Research,* Vol. 13, Nov. 1934, pages 665-676. A method is described for the preparation of pure Ga. The principal operation consists in (1) preparing a HCl solution of the metal and extracting with ether the Ga, Mo, Au, Fe, and Tl, together with small amounts of other elements; (2) precipitating Sb, As, Bi, Cd, Cu, Ge, Au, Hg, Ag, and Sn, and most of the Pb, Mo, and rhenium, with H_2S in an acid solution of the ether extract; (3) precipitating Fe and Tl with NaOH and filtering; (4) depositing the Ga electrolytically from the alkaline filtrates; and (5) eliminating the remaining impurities by fractional crystallization of the metal. Indium and Pb are the most persistent impurities, but the last traces can be removed by fractional crystallization. Ga, at least 99.999% pure, containing only very faint traces of Fe, Pb, and Ca, and having a melting point of 29.780 ± 0.005° C., was obtained. WAT (2a)

Preparation of Rare Earth Metals by Thermal Decomposition of Their Amalgams (Über die Herstellung seltener Erdmetalle durch thermische Zersetzung ihrer Amalgame). L. F. AUDRIETH. *Metallwirtschaft,* Vol. 14, Jan. 4, 1935, pages 3-5. Amalgams of Ce, La, Nd, Sm and V, containing 1 to 3% of the metals, can be produced by electrolysis of alcohol solutions of their chlorides on Hg cathodes. The amalgams are distilled in vacuum in a glass apparatus, heating slowly to 200° to 250° C. The resulting alloy contains about 15% of metal and must be kept in vacuum or CO_2 to prevent oxidation. These alloys are then heated in a high vacuum to above the m.p. to drive off all Hg. As all of the common refractory materials are attacked by the rare earths, it is necessary to use crucibles made of rare earth oxides, reinforced on the outside with clay, in which W or Mo wire heating elements are embedded. Metallic Ce, La, and Nd have been made by this method, of the same purity as the chlorides from which they were made. X-ray examination shows Ce to be face-centered cubic with a = 5.14 A.U., La hexagonal with a = 3.75, c = 6.06, and Nd hexagonal with a = 3.65 and c = 5.88. CEM (2a)

Present Day Blast Smelting of Nickel. C. C. DOWNIE. *Metal Industry,* London, Vol. 45, Aug. 31, 1934, pages 195-197. The smelting of Ni from silicate ores is described. The ore, containing approx. 10% Ni, is crushed, screened and briquetted with flux into the shape of large bricks. S is added as salt-cake, gypsum or alkali waste. The blast furnaces resemble those used by large Cu smelters. The larger ones have a capacity of 200 tons/day and the smaller ones are about half that size. The furnaces are lined with firebrick. Using ore containing approx. 10% Ni, the matte produced, consisting largely of Ni and Fe sulphides, is approx. 40% Ni matte. This is transferred to a converter which yields a product of practically pure Ni sulphide containing about 70% Ni. This is ground and roasted for conversion into cube Ni. Proper manipulation of the slag is required to permit a thorough separation of slag and matte. Supplementary processes consist in the recovery of Co and the Pt metals. Much of the Pt group is found in the furnace accretions and bottoms. The residues containing the Pt group are fluxed, concentrated into speiss by means of the D'Hennion process. This is further concentrated by sulphurizing and the precious metals separated by wet methods. Electro-refining gradually is replacing the production of Ni cubes for by the electrolytic method the purest metal is obtained and all valuable by-products are recovered. HBG (2a)

Form of Lead in Slags of Lead Blast Furnace. A. E. GUR'EV. *Non-Ferrous Metals,* Vol. 9, No. 1, 1935, pages 116-127. In Russian. Method for determination of the form of Pb in Pb slags proposed by Oldright and Miller (Bureau of Mines, Report No. 2954) is critically investigated. Ammonium acetate solution was used either slightly acid, according to Alexander's method, or slightly alkaline. Instead of natural galena, synthetic PbS was used. Acid solution dissolves PbS faster than alkaline and natural galena has a lower solubility than artificial PbS. Pb is extracted from Pb silicates relatively completely using ammonium acetate under the conditions recommended by Oldright. A cold acid solution of $NH_4C_2H_3O_2$ in 1 hour extracts silicate Pb and free oxide Pb. Accurate determination of Pb is difficult because in furnace slags Pb content is low and Pb is present in numerous compounds having different properties. Author disagrees with Oldright's statement that ammonium acetate solution does not decompose Pb silicates and Pb ferrates and that $FeCl_3$ solution does not extract Pb lead from Pb silicates. An improved scheme for Pb determination in slags is proposed. (2a)

Magnesium, a Mineral Treasure of Austria (Um das Magnesium, einen Bergschatz österreichs). *Montanistische Rundschau,* Vol. 27, Feb. 16, 1935, 2 pages. Austrian magnesite and dolomite have long been important raw materials in the manufacture of refractories. Lately attempts have been made to develop new outlet, by utilizing these ores in the production of metallic Mg. I. G. Farbengesellschaft has started an experimental plant at Bitterfeld, using crude magnesite from Tirol, and Österreichisch-Amerikanische Magnesit A.-G. has built a similar plant at Radenthein. BHS (2a)

Degtyarka Experimental Plant and Melting in the Suspended State. G. YA. LEYSEROWITCH. *Non-Ferrous Metals,* Vol. 9, No. 1, 1935, pages 94-116. In Russian. Advantages connected with melting of sulphide ores the particles of which are suspended in air led to the design of a plant utilizing this principle. A detailed description is given of the structural and operating features. (2a)

Bismuth in Copper: Its Effects, Determination, and Some Experiments in Its Gaseous Elimination. C. O. BANNISTER & W. M. DOYLE. *Bulletin Institution of Mining & Metallurgy* No. 363, Dec. 1934, 34 pages. The literature on effect of Bi on Cu is reviewed. For Cu to be used in the completely deoxidized state, Bi should be less than 0.002%; for Cu containing 0.01% O, 0.003% Bi may be present; for Cu containing 0.08% O, 0.005% Bi should not be exceeded. Methods for determination of small amounts of Bi are reviewed. A recommended method is described. Bi was eliminated from Cu by heating in H_2, N_2 or coal gas. The effect of time and temperature on the reaction is shown graphically. Sb is unaffected. AHE (2a)

Production of Manganese by Direct Reduction. Z. I. NEKRASSOV. *Domez,* No. 11-12, 1934, pages 56-60. In Russion. In laboratory experiments, Mn was reduced in solid state by H_2, solid C or their mixtures. Reduction greatly increases when Fe sponge is added to the mixture to be reduced. An oxidizing atmosphere greatly lowers the yield. No C analysis of the final products is given. (2a)

Smelting 54 Tons of Bolivian Concentrates for Tin. H. K. MURATCH & G. K. MARKAROV. *Non-Ferrous Metals,* Vol. 9, No. 1, 1935, pages 128-131. In Russian. Results of small crucible smelting of these concentrates are given. (2a)

2b. Ferrous

The Physical Chemical Basis for the Mixing of Iron Ores in the Blast Furnace Charge. Part I (Die Physikalisch-chemischen Grundlagen der Möllerung von Eisenerzen. Teil I). J. KLÄRDING. *Archiv für das Eisenhüttenwesen,* Vol. 8, Jan. 1935, pages 277-280. Intercombination of the refractory oxides in the gangue sets free the Fe oxide. The most favorable ratio of CaO and SiO_2 is $2CaO:1SiO_2$. In Ca orthosilicate the CaO and SiO_2 are bound so firmly that the reduction of Fe oxide to metallic Fe at 800°, 900°, and 1000°C. is not hindered. From the decomposition curves given it is possible to draw conclusions as to the binary diagram $CaO\text{-}SiO_2$ and the ternary diagram $CaO\text{-}SiO_2\text{-}FeO$. SE (2b)

Reducibility of Sinter Made of Krivoi Rog Iron Ores. A. N. POKHVISTNEV & M. S. GONCHAREVSKI. *Domez,* No. 11-12, 1934, pages 45-50. In Russian. H_2 reduction of sinter made from Krivoi Rog ore was more reducible than the original ore, independent of the FeO and SiO_2 content of the sinter. (2b)

Gas Distribution in Furnace Receives More Attention. *Steel,* Vol. 96, Jan. 7, 1935, pages 174, 288-289. Reviews blast-furnace progress in 1934. MS (2b)

Blast Furnace Practice in 1934. H. T. RUDOLF. *Blast Furnace & Steel Plant,* Vol. 23, Jan. 1935, pages 31-32, 40. Improvements during the past year were confined chiefly to equipment. Life of furnace lining has been increased, but there is a question as to whether this is due to better quality of refractory or to slow-blowing practice. Many installations of the automatic mud gun have been made. Refractory-filled nose tuyere and heavy nosed high-conductivity tuyere found increased use. Other developments are stove blow-off mufflers, gage rod gas seals, automatic ore bridge alinement, corrugated cinder pots, and firing of boilers with both blast-furnace gas and powdered coal. Consensus of opinion indicates that furnace of 700-800 tons capacity will be the prevailing type. MS (2b)

Clay Gun Stops Iron Notch Under Full Blast Pressure. *Steel,* Vol. 95, Dec. 24, 1934, pages 39-40. Various improvements in the automatic clay gun introduced in 1917 by Edgar E. Brosius are outlined. Latest type is a 2-motor gun with a single clay barrel, having a capacity of 9 ft.³ MS (2b)

Direct Production of Steel (La Fabrication de l'Acier direct). L. BASSET. *Usine,* Vol. 44, Jan. 31, 1935, page 31. A process is outlined for producing direct steel by burning only the quantity of C necessary for reduction, and by heating the ore with a flame which supplies heat without recarburizing the metal. A 300 ton, externally heated, rotating furnace is described. A slag more refractory than the metal and of the following suggested composition must be applied: 22% SiO_2, 8% Al_2O_3, 65% CaO; this is similar to Portland cement. 1 ton of steel requires 1400 kg. ore and 1400 kg. lime; the slag is a cement with not more than 1% Fe. The large amount of Ca permits almost complete desulphurization, 0.0008% instead of 0.05% as usual. (The editor remarks that, although this process was first described in detail in 1923, no practical application was ever made because of many practical difficulties). Ha (2b)

Deposition of Carbon in Blast Furnace Bricks (Nagra iakttagelser av kolutfällning i masugnstegel). P. J. HOLMQUIST. *Jernkontorets Annaler,* Vol. 118, Nov. 1934, pages 519-530. C deposition had caused severe destruction of bricks from a furnace in Svartå, Sweden, in the levels 4.1-8.1 meters from the top; rebuilding of the shaft was necessary after 3-1/2 years operation. The C was in the form of small rounded aggregates, similar to the spherolites. Fractures are produced by sudden expansion of these highly compressed aggregates. The original bricks contained C inclusions in chamotte grains. Fe oxide particles also were present and it appeared probable that C was formed by the catalytic action of Fe on the gases. Hence a large percentage of Fe_2O_3 in the bond is to be avoided. HCD (2b)

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3. MELTING, REFINING AND CASTING

The Foundry of Ford Motor Company at Dagenham. VINCENT C. FAULKNER & J. N. BURNS. *Foundry Trade Journal*, Vol. 51, Oct. 18, 1934, pages 235-240; Oct. 25, 1934, pages 255-259. Discussion, Nov. 1, 1934, pages 277-280. Paper read before the London branch of the Institute of British Foundrymen. The Ford foundry at Dagenham is described. This foundry, in the authors' opinion, represents an outstanding example of a manufacturing unit lending itself to intensive technical control. Should defective castings occur of any one type, the cause can be traced to the source with a minimum of expenditure of time and trouble. Under the conditions, it is usually possible to stop production, find the cause and to resume operations within 45 min. The paper is illustrated with a number of photographs. AIK (3)

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Equilibrium between Metals and Slags in Liquid State (Uber Gleichgewichte zwischen Metallen und Schlacken im flüssigen Zustand). W. KRINGS. *Zeitschrift für Metallkunde*, Vol. 26, Nov. 1934, pages 247-249. With discussion. The applicability of the law of mass action to metal-slag equilibria in the liquid state is discussed with special reference to the systems: Fe-Mn-O, Fe-Ni-O, Si-Mn-O, Fe-Si-O, Fe-P-O, Mn-P-O and Cu-P-O. The molecular state of the reacting phases is deduced in a number of instances. In discussion, Sauerwald added that he had shown good agreement with the law of mass action through activity measurements in the system Ag-Cl-Pb. 8 references. FNR (3)

7

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3a. Non-Ferrous

G. L. CRAIG, SECTION EDITOR

Replacement of Cobalt with Nickel in Pressed Hard Alloys. V. I. TRETYAKOV & N. D. TITOV. *Rare Metals*, Vol. 3, No. 1, 1935, pages 24-26. In Russian. Tungsten carbide powder is mixed with Zn dust in a small amount of aqua ammonia contained in a heated vessel provided with a stirrer. Boiling ammoniacal solution of Ni salt is added. Carbide particles coated with the deposited Ni are washed, dried and pressed. On sintering directly between C electrodes carburization occurs forming a brittle case on the outside of the sintered object. Placing them into carbon boats covered with magnesia lids before sintering prevented the trouble. Alloy containing 8% Ni had 89 Rockwell C hardness and considerable toughness. Wear tests showed resistance to abrasion equal to the usual W carbide alloys. (3a)

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Effect of Melting Conditions on the Running Quality of Aluminum Cast in Sand Molds. A. I. KRYNITSKY & C. M. SAEGER, JR. *Bureau of Standards, Journal of Research*, Vol. 13, Oct. 1934, pages 579-588. The effect of maximum heating temperature on the running quality of liquid metal has been studied for 2 grades of Al and an Al-8% Cu alloy. The running quality was measured in terms of the length of a spiral casting obtained by pouring the metal under carefully controlled conditions. The effect of various treatments of the metal was also investigated. It was found that the relation between the length of spiral and the pouring temperature is linear. The running quality of the metals which had been heated to a maximum temperature of 850° C. was in all cases less than when the metal had been heated to 750° C. Pure Al, 99.8%, was found to have markedly higher running qualities than the commercial 99.2% Al. The running quality of the Al-8% Cu alloy was not much different from that of commercial Al. WAT (3a)

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Manganese Bronze and Brass. WESLEY LAMBERT. *Foundry Trade Journal*, London, Vol. 51, Dec. 13, 1934, pages 369-372. Paper read before joint meeting of London Section of Institute of Metals and London branch of Institute of British foundrymen. Characteristics of cast alloys of the α, β and α-β phases, etc., are discussed. AIK (3a)

8

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Melting and Casting of Special Brasses (Zum Schmelzen und Giessen von Sondermessingen). W. E. HERRMANN. *Giesserei*, Vol. 22, Feb. 1, 1935, pages 52-55. Special brasses are defined as particularly hard and corrosion resistant alloys which contain, besides Cu and Zn, usually 1-3% Mn, Fe, Ni, Al and (sometimes) Sn. The usual composition is 55-57% Cu, 38-33% Zn, the remainder being additions. Care must be taken that formation of γ-crystal is avoided as the alloy is then very brittle. To obtain highest strength a 100% β-structure should be obtained which exists in the Zn range of 46-50%. To replace Zn by other metals the following equivalents must be considered: Al:Zn = 6:1, Sn:Zn = 2:1, Ni:Zn = 1.2:1, Fe:Zn = 0.9:1, Mn:Zn = 0.5:1. If the critical point of 50% Zn is exceeded, part of Zn must be replaced by Cu if the special addition cannot be changed. Proper melting and sequence of additions are important, the points to be taken into account and pouring and molding procedures are discussed. Pouring temperatures lie between 1000°-1100° C. Ha(3a)

9

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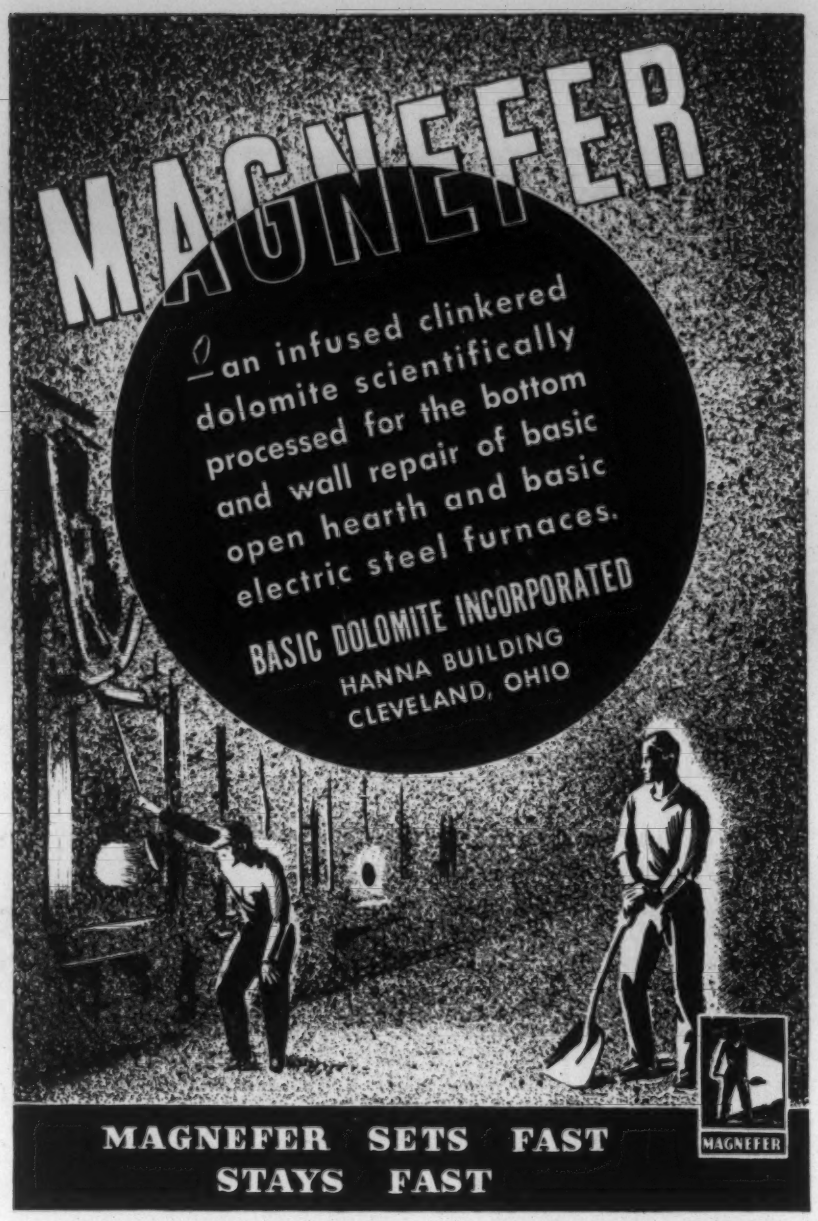
Non-Ferrous Practice. C. A. HOWE. *Foundry Trade Journal*, London, Vol. 51, Nov. 29, 1934, pages 337-339. Paper was read before the Junior section of the Lancashire branch of the Institute of British Foundrymen. Sand preparation, cores, gunmetal, brass and brazing metals, Mn bronze, phosphor bronze, Al bronze, German silver, Ni, Monel metal and white metal are discussed. AIK (3a)

10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The Aluminum Foundry (La Fonderia d'Alluminio). CARLO PANSERI. Ulrico Hoepli, Milan, 1934. Paper 6½ x 9½ inches, 582 pages. Price 65 lira.

As the author explains in the preface, this book does not pretend to give the practical "shop kinks" of an aluminum foundry; rather the author presumes a knowledge of the practical side of the art, and discusses in detail its theoretical basis. Part 1 (288 pages) covers the pertinent alloy systems, the physical properties of the metal and its alloys and the effect of temperature thereon, the melting and solidification processes, and the physical testing and metallographic control of foundry alloys. The second part gives a very good discussion of the composition, method of preparation and properties of the various aluminum casting alloys commonly used, particularly in Europe, and of aluminum bronze. The third part briefly discusses melting furnaces and technique, fluxing, degasification, and the characteristics of foundry sands. The last section discusses the factors involved in the choice of a suitable alloy and casting process, and includes a general description and comparison of the processes of sand casting and permanent mold casting, and the finishing of castings.

This is probably the most complete discussion of the aluminum casting art, from the metallurgical standpoint, that has been published anywhere in the world. The numerous photo-micrographs and other illustrations are very well chosen and are exceptionally well reproduced on high quality paper. The whole book gives the impression of a high technical ability and thorough knowledge of the field, combined with a careful attention to detail, and commendable accuracy. Any metallurgist interested in aluminum casting and conversant with Italian will find this book very interesting and valuable. Francis C. Frary (3a) -B-

Melting Control Reduces Losses. N. K. B. PATCH. *Foundry*, Vol. 63, Jan. 1935, pages 22-23, 56. Proper melting in non-ferrous foundries is as important as molding, core making or any other step in making castings. The essential steps that require experienced control in production of good castings are: (1) metal melting; (2) molding and core making; (3) gating the mold to insure proper flow of metal; (4) provisions for feeding casting during solidification by providing necessary risers; and (5) pouring metal at proper temperature. Melting control will increase the efficiency of melting and reduce defectives. VSP (3a)

Determination of Castability of Aluminum Alloys (Ein Beitrag Zur Bestimmung der Giessbarkeit an Aluminium-Legierungen). A. VON ZEERLEDER & R. IRMANN. *Zeitschrift für Metallkunde*, Vol. 26, Dec. 1934, pages 271-274. The use of the spiral casting test of Courty (*Revue de Métallurgie*, 1931) for determining the most favorable conditions of composition, metal temperature, and mold temperature for the production of sand castings of a maximum soundness and strength combined with a maximum fluidity of the metal, is demonstrated with the alloys: Al-Si (0-12%), Anticorodal (Al, 0.6% Mn, 0.6% Mg) with additions of 2 and 5% Si, and Anticorodal with 2% Si and 0-2% Sb. FNR (3a)

3b. Ferrous

C. H. HERTY, SECTION EDITOR

Reworking of Copper Scrap (Zur Umarbeitung von Kupferabfällen). WERNER FRÖHLICH. *Chemiker-Zeitung*, Vol. 58, Nov. 14, 1934, pages 920-921. Pure Cu can be judged by its color, but it is best to remelt Cu from unknown sources before using. If Cu wire is used for making castings it should be deoxidized with phosphor Cu or Mn-Cu. Thin wire should be pressed into bundles to reduce oxidation. Sheet scrap should also be pressed and the oil burned off. Cu segments may contain Si. This should be removed by oxidation by heating to 1200° C. and adding Cu scale, then deoxidizing with phosphor Cu. Al can be removed in the same way. CEM (3a)

Blast Furnace Smelting of Tin Residues. C. C. DOWNIE. *Metal Industry*, London, Vol. 45, Aug. 10, 1934, pages 123-124, 137. The recovery of Sn from waste material is much more complicated than the extraction of this metal from the ore because of the presence of variable amounts of Sn, Pb, and Sb, unless great care is exercised, a large amount of the metal is lost in slag, skimmings, etc. Skilled smelters are necessary. The sources of raw material are mentioned and the approx. analyses of a number of drosses are given. Residues are frequently briquetted by mixing with cement containing sufficient sand to act as a binder. It is mixed as a slurry, allowed to dry, broken up with picks and charged into a blast furnace. Fe slag is added as a flux with a small percentage of white metal or material rich in As. The Fe content is very important and accurate fluxing is necessary in order to liberate the Sn oxide. The first charges of a blast furnace are rich in Pb and, after the furnace is going properly, charges successively richer in Sn are added. A mixture of foundry and gas-coke gives the best results. Sometimes Pb dross is added to increase oxidation. If the slag is too basic, the Sn acts as an acid and enters the slag; while if it is too acid, Sn silicate is formed. The usual products obtained by this process are a Sn-Pb alloy, white metal, slag and fume. The Al methods are used to remove Sb. While this method is costly, it acts as a short cut. Water causes the evolution of hydrogen arsenide and so must not be present. Different methods are used in tapping. Furnace accretions are avoided by working Pb drosses containing little Sn after the Sn-rich drosses have been consumed. Antimonial charges cut the bed most cleanly but sometimes the bed is heavily corroded in this manner. Fireclay linings will not withstand this corrosion as well as magnesite and chromite but the latter are more expensive. HBG (3a)

Operations at the Lead Plant of the U. S. Metals Refining Co. RICHARD P. E. HERMSDORF. *Mining & Metallurgy*, Vol. 15, Dec. 1934, pages 477-480. Describes the plant of the United States Metals Refining Co., Carteret, N. J. VSP (3a)

Advanced Die Design Extends Field of Die-Casting. CHAS. O. HERB. *Machinery*, N. Y., Vol. 41, Feb. 1935, pages 329-334. Better steels have made possible application of die-casting to many parts of intricate forms. Design, casting methods and materials used are discussed briefly and examples shown. Ha (3a)

Extraction and Recovery of Palladium. C. C. DOWNES. *Industrial Chemist*, Vol. 10, Sept. 1934, pages 355-356. The recovery of Pd as a by-product from the electrolysis of Ag is described. RAW (3a)

Carbon Loss and Pick-up in the Cupola. H. H. LANGEBECK. *Metals & Alloys*, Vol. 6. Feb. 1935, pages 31-34, 38. A correlated abstract, translated by James T. MacKenzie. Summary of data available shows that though there is a relation between C content of charge and melt this relation is not simple. Coke tends to carburize in proportion to amount of surface exposed, CO formed, rate of burning and inversely proportional to ash. Volume and velocity of wind appear to have no definite relation to carburization though high velocities appear to be useful in obtaining low C values. WLC (3b)

Oxide Impurities in Steel (Über oxydische Beimengungen im Stahl). FRIEDRICH KÖRBER. *Zeitschrift für Metallkunde*, Vol. 26, Nov. 1934, pages 241-244. This brief summary of the results of an extensive investigation of the equilibria between Fe-FeO saturated solution and various slags and deoxidizing agents presents graphically the following data: (1) the solubility of O_2 in Fe as a function of temperature (a linear dependence from $\frac{O_2 \times 100}{FeO} = 0.22$ at 1525° C. to $\frac{O_2 \times 100}{FeO} = 0.8$ at 2000° C); (2) the O_2 content of Fe as a function of the FeO content of $FeO\text{-}MnO\text{-}SiO_2$ and $FeO\text{-}CaO\text{-}SiO_2$ slags (a linear dependence from 0% O_2 at 0% FeO in the slag to 0.11% O_2 at 52% FeO in the slag, the two slags giving identical values); (3) the O_2 content of Fe as a function of the Mn content of the Fe and the temperature; (4) the O_2 content of Fe as a function of the Si content of the Fe and the temperature; and (5) the O_2 content of Fe as a function of the Mn + Si content of the Fe at 1600° C. FNR (3b)

Refractory Materials for Blast Furnaces. ALFRED B. SEARLE. *Blast Furnace & Steel Plant*, Vol. 22. Sept. 1934, pages 540-541; Oct. 1934, pages 600-601; Nov. 1934, pages 660-661. From *Metallurgia*, Jan. 1934, page 85. See *Metals & Alloys*, Vol. 6, Jan. 1935, page MA 4. MS (3b)

Properties of Gray Cast Iron as Affected by Casting Conditions. C. M. SAEGER, JR. & E. J. ASH. *Bureau of Standards Journal of Research*, Vol. 13, Oct. 1934, pages 573-577. A report of a preliminary investigation to determine the effect of maximum heating temperatures on the physical properties of different types of cast Fe. The methods and results obtained on 3 types of cast Fe are given. See also *Metals & Alloys*, Vol. 5, July 1934, page MA 318. WAT (3b)

Finishing the Heat of Steel. Pts. XXVII, XXVIII, XXIX. J. H. HRUSKA. *Blast Furnace & Steel Plant*, Vol. 22, Dec. 1934, pages 699-701; Vol. 23, Jan. 1935, pages 67-68; Feb. 1935, pages 124-125. **XXVII.** Discusses effect of ingot size on percentage of segregation, location of richest segregates in ingots and effect of mold thickness on ingot structure. Includes results of author's investigations. **XXVIII.** Deals with crystallization and amount and composition of non-metallic inclusions in ingots. Tabulates results of analyses by different investigators. **XXIX.** Deals with the crystalline structure of ingots. MS (3b)

Estimating O. H. Slag Composition. I. N. Goff. *Blast Furnace & Steel Plant*, Vol. 22, Nov. 1934, pages 640-641, 656; Dec. 1934, pages 693-694. Knowledge of the FeO, Fe_2O_3, and MnO content of open-hearth slags will give the metallurgist sufficient information about his slag composition for the proper working and finishing of his heat. These constituents can be determined easily, accurately, and rapidly by titration methods. FeO is determined by titration with $KMnO_4$. Fe_2O_3 is calculated from the total Fe, which is determined by titration with either $KMnO_4$ or $K_2Cr_2O_7$, after reduction of ferric ions to ferrous by $SnCl_2$. $K_2Cr_2O_7$ is preferable. Arsenite titration method on a small aliquot sample is used for MnO. As a good relationship between sp.gr. and composition of slag was found, amount of these oxides can be estimated in a still shorter time by a single determination of the sp.gr. of an 80-mesh powdered slag sample. Gives details of the methods of making these determinations and comments on their accuracy. Suggests that balance of slag composition can be estimated by referring to prepared charts. MS (3b)

Centrifugal Casting (La Centrifugation). A. Guédras. *Revue de Fonderie Moderne*, Vol. 29, Jan. 25, 1935, pages 18-23. A historical sketch of the development of centrifugal casting is given and the processes used at present, materials for the rotating molds, and advantages and properties of the cast pipes are discussed. Ha (3b)

The Physical Chemistry of Steel Making. Extended Abstract of Final Reports to the Metallurgical Advisory Board. S. Epstein. *Metals & Alloys*, Vol. 6, Mar. 1935, pages 71-77. 19 references. Briefly summarizes the work of C. H. Herty, Jr. and his associates in various aspects of physical chemistry of steel making including FeO control in basic open-hearth process, purpose of slag control, deoxidation of steel, Mn/Si ratio, determination of inclusion content, grain size and aging and cause of fine grain. WLC (3b)

Notes on the Basic Open-Hearth Process; A Consideration of Slags. J. M. Ferguson. *Iron & Coal Trades Review*, Vol. 130, Jan. 18, 1935, pages 130-131; Jan. 25, 1935, pages 170-172. Conducting of refining actions in the basic open-hearth process were studied. Conditions necessary for effective bath control require finishing slags of a tribasic order with reference to the acidic oxides which they contain; such control is increased by high bath temperatures. Control by the operator is opposed by the effects of "gas oxidation" which occurs to an extent depending on prevailing conditions of slag basicity and bath temperature; the gas oxidation losses increase with slag acidity and low bath temperatures. Maximum S elimination can be secured only if the basicity of the slag is high; the S content of a bath indicates, therefore, usually that refining action has been correctly controlled and that the basic conditions of the bath are good. Ha (3b)

Nickel Wrought Iron, A New Product. E. F. Cone. *Iron Age*, Vol. 135, Jan. 24, 1935, pages 22-24. Discusses the cycle of operations in the manufacture of Ni wrought Fe at the A. M. Byers Co. plant by the Aston process. To produce the Ni-Fe, Ni is added to molten Fe in amount necessary to give desired composition. Wrought Fe containing up to 5% Ni is possible, but for most practical purposes 3% or under is most satisfactory. Gives chemical analysis of a Ni wrought Fe. Feature of Ni wrought Fe is that its properties can be enhanced by heat treatment. Includes data on relative fatigue properties of low-Mn steel, wrought Fe and Ni wrought Fe. There are many possible uses for Ni wrought Fe. Principal use so far is for sucker rods in oil industry. VSP (3b)

Correct Determination of the Value of the Material of Castings (Die richtige Ermittlung des Stoffwertes von Metallgussteilen). Erich Becker. *Die Giesserei*, Vol. 22, Jan. 4, 1935, pages 3-6. The importance of correct determination of material in a casting and the influence of it on the evaluation of scrap and determination of factory costs is pointed out. Ha (3b)

Difficulties of measuring the Temperature of Molten Steel. R. S. Whipple. *Engineering*, Vol. 138, Nov. 16, 1934, pages 541-542. From paper read before Sub-section AG of the British Association for the Advancement of Science, Aberdeen, Sept. 6, 1934. LFM (3b)

Making Quality Steels. Emil Gathmann. *Blast Furnace & Steel Plant*, Vol. 23, Jan. 1935, page 73; Feb. 1935, pages 137-139. Emphasizes importance of process inspection in tonnage production of quality steels. Big-end-up molds are necessary for the production of quality steels, but have not heretofore been in universal use for all grades of steel because suitable stripping and handling means were not available. Today there is available new apparatus whereby it is possible to produce and strip big-end-up ingots of rimming, semi-killed and fully-killed steels with the same basic equipment heretofore used in big-end-down production. MS (3b)

Influence of Treatment of Melts by Slags High in Ferrous Oxide and Acidic Slags Low in Ferrous Oxide on Crystallization and Mechanical Properties of Gray Cast Iron (Einfluss der Schmelzbehandlung durch eisenoxydul-reiche und saure oxydularme Schlacken auf die Kristallisation und die mechanischen Eigenschaften von grauem Gusseisen). P. Bardenheuer & A. Reinhardt. *Giesserei*, Vol. 22, Feb. 1, 1935, pages 45-52. See *Metals & Alloys*, Vol. 5, Aug. 1934, page MA 385. Ha (3b)

Foundry Methods from an Engineer's Point of View. F. Williams. *Foundry Trade Journal*, London, Vol. 51, Nov. 29, 1934, pages 341-343. Paper read before joint meeting of Sheffield and East Midlands of the Institute of British Foundrymen. Drawn castings, hydraulic castings, making segmental castings, core stroking, etc., are discussed. AIK (3b)

Experiences in the Manufacture of High Grade and Alloy Cast Irons. P. A. Russell. *Foundry Trade Journal*, London, Vol. 51, Dec. 6, 1934, pages 353-356. Paper read before Joint meeting of London and East Midlands branches of Institute of British Foundrymen. Cupola conditions, feeding low-carbon irons, introduction of alloys, casting austenitic cast irons etc. are discussed. AIK (3b)

Chemistry of an Open-Hearth Heat. L. H. Nelson. *Blast Furnace & Steel Plant*, Vol. 22, Dec. 1934, pages 687-688, 698; Vol. 23, Feb. 1935, pages 126-128, 136, 150. Discusses chemical reactions taking place in an ordinary basic open-hearth heat. States the sources of oxygen and explains the manner in which C, Mn, Si, P, and S are oxidized and eliminated. MS (3b)

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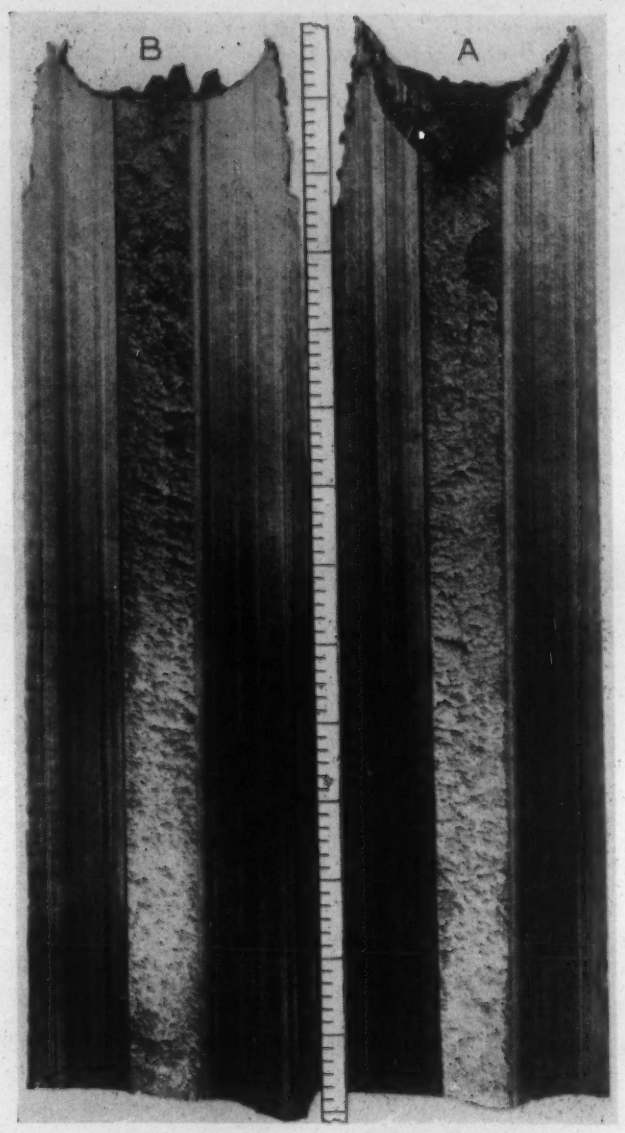

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4. WORKING

Practical Metallurgy, Second Part: Forming without Cutting (Praktische Metallkunde, Zweiter Teil: Spanlose Formung). G. SACHS. Julius Springer Verlag, Berlin, 1934. Cloth, 6¼ x 10 inches, 238 pages. Price 18.50 RM.

This second volume of "Praktische Metallkunde" is an outline of the principles and practice of metal forming. Three fourths of the book is devoted to the physical metallurgy of cold working, hot working, and annealing, to the mechanics of deformation, and to the measurement and relief of internal stresses. The last fourth of the book discusses the forming operations: the general principles of the machines used, the operating conditions, the force requirements, the stress distributions encountered, the materials used, the more common types of failures encountered, and the metallurgical characteristics of the final products. The methods covered are extrusion, forging, stamping, upsetting, rolling, reeling, spinning, wire drawing, tube drawing, and deep drawing.

Sachs spans in this one small book the whole distance from pure science (the crystallography of deformation in single crystals, for example) to modern plant practice, so the discussion of each subject is necessarily limited to a few pages on general principles. But the result is not a weak or disjointed treatment. It is a connected account of the metallurgical and mechanical studies upon which has been built the highly developed art of today. As is usually the case with Sachs' books, there are a tremendous number of journal references (an average of about eight per page throughout the book), and the German is in his simple direct style that is about as easy to read as German can be made. As an introduction to the field and a guide to further reading, the book is probably without an equal; but for those already active in the field, or those interested in details, it is disappointingly brief—amounting, in fact, to scarcely more than an excellent bibliography welded together by well considered summary statements.

C. S. Barrett (4) -B-

4a. Rolling

RICHARD RIMBACH, SECTION EDITOR

Manufacture and Some Uses of Nickel-Clad Steel. HERBERT R. SIMONDS. *Iron Age*, Vol. 135, Jan. 24, 1935, pages 14-17. Usual proportion of thickness of Ni to steel in clad plate is 1 to 9, although cladding may range from 5% Ni on heavy plates to 4%. Sand blasting is an important procedure. Two pairs of plates are rolled together, that is, two steel plates and two Ni plates, the steel plates being on the outside with parting compound between Ni plates. Projecting ends of steel plates are electrically welded together. Plates are heated and rolled at temperature of 2300° F. There are numerous uses for Ni-clad steel. VSP (4a)

Large Expenditures Made for Wide Strip Mills. *Steel*, Vol. 96, Jan. 7, 1935, pages 167-168, 285-286. Reviews developments in rolling-mills during 1934, with chief attention to construction activities. MS (4a)

Counter for Reversing Cold Strip Mill Indicates Number of Wraps on Reel. F. MOHLER. *Steel*, Vol. 95, Dec. 3, 1934, page 40. Gives schematic diagram of an electrical indicator, incorporating Selsyn devices. MS (4a)

Lubrication of Rolling Mill Gear Units. THOMAS HOLLOWAY. *Iron Age*, Vol. 133, Feb. 1, 1934, pages 21, 78. Abstract of portion of paper read before the Association of Iron and Steel Electrical Engineers at Pittsburgh. First part of paper "Rolling mill reduction gears units" was published in *Iron Age*, Jan. 25, 1934, pages 26-28. Discusses the lubrication of rolling mill reduction gear units. For units with moderate pressures the splash and flood system is practical. Drives with gears under heavy pressures should be designed for splash for the gears and ring oil from separate reservoirs for the bearings. Where gear units are in close proximity and service conditions similar one central system is satisfactory. Anti-friction bearings are preferred because heavier lubricants may be used. VSP (4a)

Reversing Drives for Blooming Mills. GORDON FOX. *Blast Furnace & Steel Plant*, Vol. 22, July 1934, pages 383-388; Aug. 1934, pages 445-448; Sept. 1934, pages 515-519; Oct. 1934, pages 572-576; Nov. 1934, pages 629-632; Dec. 1934, pages 689-692, 697; Vol. 23, Jan. 1935, pages 63-65. From a brochure prepared for publication in the U.S.S.R. Discusses electric driving of blooming-mills. Points out some important differences between American and European practice. MS (4a)

High Speed Features New Sheet Roughing Mill. *Iron Age*, Vol. 134, Dec. 20, 1934, pages 22-24, 76. Describes a new three-high roughing unit to be erected at Jamshedpur, India for the Tata Iron & Steel Co. Special feature of the unit is its speed. It employs mechanized mill tables operating in connection with continuous furnaces and it is electrically controlled. Mill is designed to rough 12 in. width sheet bars in 5 passes to No. 15 or 16 gage in about 14 sec. minimum. Considers also the development of sheet rolling by the Tata Iron & Steel Co. VSP (4a)

Evolution of the 12-High Cold-Rolling Mill. *Iron & Coal Trades Review*, Vol. 130, Jan. 25, 1935, pages 165-166. The problem of improving the quality of the product when manufacturing large quantities as applied particularly for thin sheets is discussed and it is shown how the development of a 12-high mill with a working roll of very small diam. and 5 large backing rolls solves the problem of slip reduction and lower power requirements. Fe and Ni sheets of 0.0004" (0.01 mm.) and Cu sheets of 0.00031" (0.008 mm.) were obtained without difficulty with a working roll of 0.4" (10 mm.) diam. Operating results are given in detail. Ha (4a)

Flow Hardening in Cold Rolling. W. TRINKS. *Blast Furnace & Steel Plant*, Vol. 23, Feb. 1935, page 139. For the purpose of stimulating discussion, summarizes various reasons advanced to explain ability to elongate steel enormously by cold rolling without annealing. Among these are improved quality of steel; better blooming-mill practice; random orientation of the crystals; steel will flow harden only to a certain limit by elongation and, if rolling be continued beyond that limit, it hardens no more; steel, once flowing in a pass, can flow a large amount with no more hardening than would occur if it flowed a small amount per pass; pulling steel through rolls by means of a reel or a set of pinch rolls; use of backward tension; and use of small rolls. Some of these are statements of fact, without reasons therefor. MS (4a)

Refinements in Control Speed Operation of New Billet Chipping Machine. *Steel*, Vol. 95, Dec. 3, 1934, pages 24-26. Describes improved machine developed by the Bonnot Co., Canton, O., for removing surface defects from billets for seamless tubes at a total cost of 40-60 cents per net ton. Cleaning is done by high speed steel cutting-tools mounted in a milling-type head. Principal improvement is a handle with 8 contactors which control the movements of the cutting head and work carriage. MS (4a)

Developments in the Rolling of Sheets and Strip. 1934. STEPHEN BADLAM. *Iron & Steel Engineer*, Vol. 11, Dec. 1934, pages 500-510. Improvements are likely in more rigid specifications of quality, physical characteristics, gage and surface. Some economies outside of pure rolling may be achieved. Big problem is equipment capable of producing sheet or strip 100" wide. WLC (4a)

Solving Production Problems With Conveyors. M. J. ANDERSON. *Tech Engineering News*, Vol. 15, Jan. 1935, pages 128-129, 136. Strip steel sent from rolls to annealers and finish on conveyor belts. Coiling of strip after finish roll by means of conveyor which twists 90°. WB (4a)

Manufacture of Full-Finished Steel Sheets. ERIC R. MORT. *Sheet Metal Industries*, Vol. 8, Oct. 1934, pages 565-569. See *Metals & Alloys*, Vol. 5, Oct. 1934, page MA 474. AWM (4a)

4b. Forging & Extruding

A. W. DEMMLER, SECTION EDITOR

The Heavy Forge Department of The English Steel Corporation, Limited. *Engineering*, Vol. 139, Feb. 15, 1935, pages 161-164. Describes the equipment of the forge department of the corporation organized in 1929 by the consolidation of the interests Vickers, Ltd., W. G. Armstrong, Whitworth & Co., Ltd., and Cammell Laird & Co., Ltd. VSP (4b)

Forgings Makers Are Meeting Exacting Specifications. *Steel*, Vol. 96, Jan. 7, 1935, pages 152, 269. Reviews progress made in 1934 in the forgings industry. MS (4b)

4c. Cold Working, including Shearing, Punching, Drawing & Stamping

Metal Spinning—Applications of the Spinning Process and Materials Employed—Hand Spinning Operations—Finishing Drawn Parts by Spinning. W. RICHARDS. *Machinery*, London, Vol. 45, Jan. 24, 1935, pages 565-569; Jan. 31, 1935, pages 601-605. The first article involves the behavior of various metals in spinning. The second involves the finishing of drawn shells by spinning and the equipment for trimming and curling. WB (4c)

Trend in Stampings Toward Larger, Complicated Designs. *Steel*, Vol. 96, Jan. 7, 1935, pages 154, 270. Survey of 1934 developments in the stampings industry. MS (4c)

4d. Machining

H. W. GRAHAM, SECTION EDITOR

Mechanical Treatment of Electro-Deposited Coatings. *Engineering*, Vol. 139, Jan. 25, 1935, page 101. Building-up of metal parts by electro-deposition, followed by milling and grinding has been increasing. Ni and Cr deposits are most used, although Fe can give a hard deposit. Other metals that may be used are Pt-Ir and Pt-Rh, but their high costs prohibit their commercial use. Both machines and tools used are carefully selected that any deposit may be rapidly and accurately handled. It is important that hardness be tested by one of the approved methods before milling the section. Ni, Cr and Fe deposits can be machined dry, and use of lubricant is only necessary to preserve cutting edge of tool. High cutting speeds have not been successful. Surplus material is removed by grinding. Ta-carbide and Ta tipped tools are best for Ni and Cr, respectively. VSP (4d)

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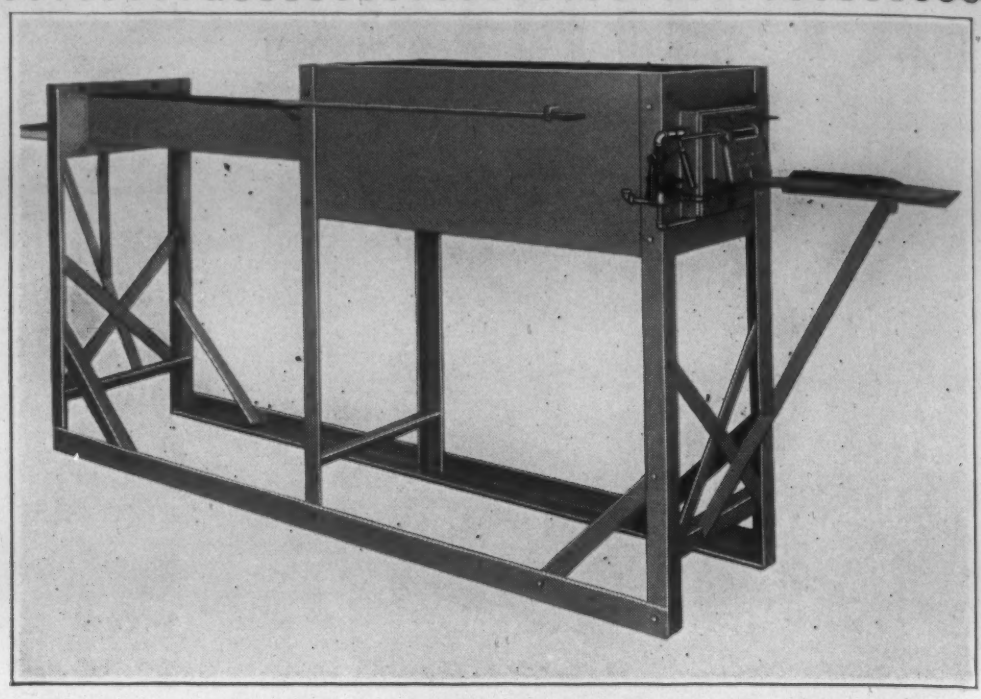

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5. HEAT TREATMENT

O. E. HARDER, SECTION EDITOR

Control of Scale Formation in Heating Steel. T. B. Bechtel. *Iron & Steel Engineer*, Vol. 12, Jan. 1935, pages 26-27. Description of equipment used for steel wire, screws, stamps and strip. WLC (5)

Prevention of Explosions of Nitrous Salt Melts for Heating Metals (Verhinderung der Explosion von salpeterhaltigen Salzschmelzen zum Vergüten von Metallen). W. Beck. *Aluminium*, Vol. 17, Jan. 1935, pages 3-6. While baths consisting of saltpeter are widely used in the steel industry for heat-treatment without danger, explosions have occurred when using the same baths for light metals. The actual cause for such explosions was found not to be due to a reaction between the immersed metal and the nitrous melt within the iron bath container, but that the explosion occurs in the heating space after an abnormal destruction of the bath container. The reason is that at a bath temperature of about 650° C. a violent reaction between saltpeter and the iron container takes place with strong gas development, rapid erosion of the container and sudden penetration of larger amounts of niter into the heating space. Here the gases explode, if they can not escape quickly enough through chimneys, with disastrous consequences. A temperature of 500° C. should never be exceeded in such a bath. At higher temperatures, reactions can also occur as the light metals act almost as catalyzers in the disintegrations of O and N at high temperatures in an enclosed space. Heating from the outside (gas, oil, electric) should not be permitted, immersed electric heating elements are safer. A number of explosions and a furnace design with enclosed immersion elements are described. Ha (5)

Heat Treatment of Cast Iron. John W. Bolton. *Foundry*, Vol. 62, Aug. 1934, pages 18-20, 48; Sept. 1934, pages 16-18, 56, 59. Includes a bibliography. Heat treatments of gray Fe are undertaken either to relieve internal stresses or to change structural constitution and modify the physical properties of metal. Explains structural changes taking place. Gives charts showing reaction of Fe at different temperatures, cast Fe cooling curve expansion and contraction effects and comparative stress-strain diagram of gray Fe at elevated temperatures. Author concludes that: (1) Oil or water quenching gray Fe from above critical temperatures results in increase in hardness. Common quenching range is 1500° to 1550° F. for plain Fe, however strength is impaired and metal is brittle. (2) On drawing little change, except possible removal of some embrittlement is noted on draws up to 350° F. Above that point gradual softening and regaining of strength are noted. (3) Quenching and drawing suitable only with base irons, preferably C under 3%. (4) Highly complicated designs should be avoided. (5) Properly quenched and drawn cast Fe has fine silky grain. Reviews experiments of other investigators. VSP (5)

Heat Treatment of Rainbow's Stay Braces. Horace C. Knerr. *Iron Age*, Vol. 134, Sept. 27, 1934, pages 30-31. Describes the use of heat treated steel stay braces in place of cable which is new in yachting practice. They are of Cr-Ni electric furnace steel, S.A.E. 3240. These rods present a difficult heat 7 treating problem because of their great length slimness, high strength and other exacting requirements. To remove internal stresses and refine structure resulting from hot forging, rods were normalized by heating to 1550-1600° F. after normalizing rods were reheated to 1450-1500° F., held from 20 min. to 1 hr. and quenched in oil. Finally tempered for 1 hr. or longer at 750° F. Heat treatment was done by "Metlab" in a vertical electric furnace. Test results ran from 190,000 to 210,000 lb./in.², with elongation of 13% to 11% in 2 in. VSP (5)

5a. Annealing

8

Short Cycle Anneal for Malleable. Gottfrid Olson. *Foundry*, Vol. 62, Oct. 1934, pages 49-51, 107. Author believes that short anneal malleable can be made as good as regular malleable. There is no longer any doubt as to what happens at certain temperatures and so there should be no doubt as to time required for annealing. Investigations show that absorption of Fe_3C into solid solution requires 3 hrs. at 1832° F., 10 hrs. at 1742° F., and 30 hrs. at 1652° F. No appreciable amount of precipitation takes place above 1500° F. and maximum is reached around 1365° F. Shortening annealing cycle is simply a matter of 9 temperature control. To shorten annealing time it must be determined which of 4 periods may be shortened, and how much can the time be reduced. Chemical composition and temperature of Fe are important in determining annealing time. It is also claimed that superheating Fe tends to reduce annealing time. Gives an account of workings of an oven which is not in accordance with desired practice but with the idea of showing how not to operate oven. Gives useful charts and tables. VSP (5a)

Clean Annealing at Motor Wheel Corporation. A. G. Seger. *Heat Treating & Forging*, Vol. 21, Jan. 1935, pages 11-12. Steel stampings are annealed in 10 a full-muffle type, continuous, controlled atmosphere furnace. Conveying mechanism is of the walking-beam type. Heating zone is 15½ ft. long. Cooling zone is 25 ft. long and has H_2O-cooled walls. Time of travel through the furnace averages 22 min. Work is heated to 1450°-1600° F. and is discharged at about 400° F. Atmosphere is prepared by partial combustion of C_4H_{10} and air. Rated capacity is 2160 lb. of clean annealed stampings/hr. MS (5a)

Normalizing Process Perfected for Rails. JOHN BRUNNER. *Railway Age*, Vol. 98, Mar. 2, 1935, pages 325-328. Normalizing of rails is considered to have eliminated the conditions which give rise to transverse fissures and other interior defects. Impact resistance of rails decreases rapidly as the temperature decreases, particularly in rails having hardening properties such as are required by current specifications. Investigations showed that the failures of rail from fracture at low temperature and fatigue failure from repeated stress invariably started in the coarser grain of the interior and then spread to the surface. Refining of this coarse internal structure was believed to be a cure for this type of failure. The normalizing process was considered best for this purpose because it not only refines the structure but also prevents the formation of shatter cracks and at a fairly low cost. The process consists of air cooling after leaving the rolls until interior is slightly below thermal critical range but above brittle range. Then rails are reheated in furnace until entirely above thermal critical range and removed from the furnace whereupon hardening of both ends is effected by air quench. Stress contours are plotted for rail cross-section from data obtained by sawing rail into strips parallel to rolling direction. The strips have a cross section of diamond shape and are exactly 90° to the accurately planed rail end. The contraction or elongation of the strips due to compressive or tensile stresses is used as a measure of these stresses. Stress contours are shown for the normalized, slowly cooled and hot-bed cooled rails and also for rails that had been in service for a number of years. Stress lines in rails in service change and move upward toward or beyond the center of the rail head. Normalized rails have practically the same hardness, 250-260 Brinell, as hot-bed cooled rails. Air quenched ends can be brought up to 375-400 Brinell. The heat in the rail is used to draw back the ends after air quench. Increase in ductility and impact resistance has been noted for normalized rails. WB (5a)

Spheroidizing Steels. JOSEPH A. DUMA. *Heat Treating & Forging*, Vol. 20, Dec. 1934, pages 583-585. Procedure for spheroidizing steels is given. Preliminary cold work reduces time of treatment 85%; sorbitizing, 50%; Pb quenching, 50%; and liquid hardening, 40%. Steels become less easily spheroidized as C increases from 0.20-0.25% to eutectoid percentage. Resistance of eutectoid steels to the treatment can be readily overcome by causing the temperature to oscillate back and forth through the critical range. Finely laminated pearlite with semi-segregated Fe_3C and sorbitic pearlite with emulsified Fe_3C form very minute globules under the treatment. Coarsely laminated structures with completely segregated Fe_3C form very large globules. Kourbatoff's alkaline $NaC_6H_2(NO_2)_3$ and Murakami's alkaline $K_3Fe(CN)_6$ are the most dependable reagents for developing spheroidized structures. Spheroidization increases machinability, abrasion resistance, and creep, and decreases impact strength. Steel spheroidized prior to hardening will give minimum warpage and maximum freedom from quenching cracks during hardening. Steel exposed to service temperatures of 800°-1200° F. continually will eventually spheroidize. MS (5a)

5b. Hardening, Quenching & Drawing

Continuous Controlled-Atmosphere Furnace Used to Harden Automobile Valve and Clutch Springs. F. L. PRENTISS. *Iron Age*, Vol. 135, Jan. 31, 1935, pages 33-35. Describes the hardening of high-grade automobile and clutch springs and other mechanical springs at plant of Cleveland Wire Spring Co. Valve springs are made from SAE 6150 (Cr-V) spring steel or Swedish valve spring wire equivalent to SAE 1065. Most clutch springs are made from SAE 1360 C spring steel wire. The hardening furnace is divided into 3 zones each of which is independently controlled. The first zone is for preheating, temp. of about 1400° F., the second zone, temp. of 1500° F., and third zone or soaking zone. Time that springs are kept in furnace varies depending on type of springs. Drawing temp. ranges from 600° to 900° F. Springs made of pre-tempered wire are bake-tempered in chamber type furnace. As preventive against rust the springs are blued in Homo furnace. VSP (5b)

Temper-Hardening Copper Alloys. MAURICE COOK. *Metal Industry*, London, Vol. 45, July 27, 1934, pages 83-87; Aug. 3, 1934, pages 101-105; Aug. 10, 1934, pages 134-136. Paper read before the Midland Metallurgical Society in Birmingham Feb. 13, 1934. The mechanism of aging is discussed. "Age-hardening," used as a comprehensive expression to indicate changes in properties at room temperature or on tempering, after quenching, is deemed unsuitable, and "temper-hardening" is suggested. The different theories of "age-hardening" are compared and discussed. Examples are given where hardening is, and is not, accompanied by precipitation and abnormalities are commented upon where increases in hardness are not accompanied by increased strength. A list is given showing what additions to Cu produce "temper-hardenable" alloys. These are grouped into (1) the alloys containing nickel-silicide additions, (2) the Cu-Be alloys and (3) Cu alloys with additions of Ni and Al. Reference is made to the work of a number of investigators who have studied Cu alloyed with a number of these additions. Tables of physical properties of a number of these alloys, plotted data, micrographs and a large bibliography are included. Practical applications of these alloys are considered. HBG (5b)

Heat Treating Steel Castings. JOHN D. KNOX. *Foundry*, Vol. 63, Feb. 1935, pages 22-23, 53; *Steel*, Vol. 95, Dec. 3, 1934, pages 42, 45. Both C and alloy steels show improved physical properties when heat treated by quenching and tempering. Compared to annealed steel castings the elastic limit is increased about 45%, ultimate strength 25% and impact about 100%. Machinability is also improved. At plant of Bonney-Floyd Co., Columbus, every facility is provided for controlling various steps in process. Thoroughly refined metal is important. Cast steel articles must be heated uniformly and at proper temperature before quenching. Finally temperature at which castings are removed from quenching bath has an important bearing on results. In heat treating small bevel gears each end of bore is plugged to draw the center to desired temperature. Increases in allowable fiber stress in cast machine parts permits use of heat treated low C steel to reduce weight and cost of castings. Includes tables giving physical values of plain C cast steel and changes by annealing and heat treating. VSP + MS (5b)

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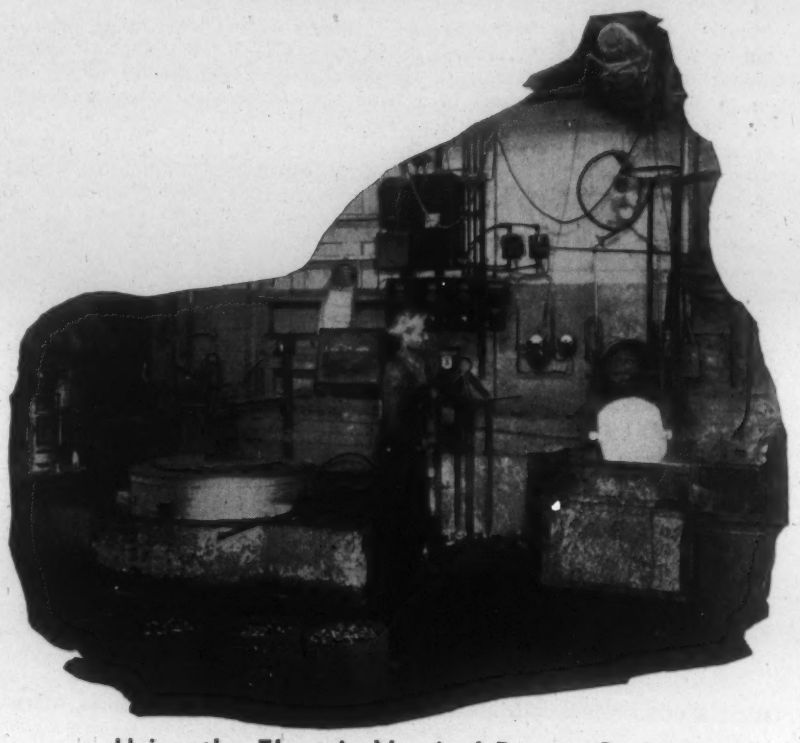

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Hardening Intricate Shapes of Tool Steel. MATTHEW L. CLARK. *Heat Treating & Forging*, Vol. 20, Dec. 1934, pages 591-592. To harden intricately shaped tool-steel containing 0.95-1.1% C and 0.20-0.25% V, without distortion, steel is normalized at 1500° F. by placing in furnace at a temperature under 800° F., equalizing with furnace temperature, and raising temperature at a rate of 1¼ hr./in. thickness. Charge is cooled in still air to below red heat, and placed back into furnace. It is heated to 1390° F. at the same rate as previously. Steel is allowed to cool in furnace until morning and then may be air cooled. Before hardening, all scale must be removed from furnace. Tools are strung by wires, so that they will not touch, cleaned, placed into furnace with temperature below 700° F., equalized with furnace temperature, and heated to 1380° F. in 1 hour. They are quenched vertically, without agitation, in brine having a temperature of 68°-72° F., made up of 1 gal. of saturated brine and 8 gal. H_2O. They are drawn at 360° F. for 2 hours. MS (5b)

Doppel-Duro Method for Surface Hardening (Doppel-Duromethoden för ythärdning). *Teknisk Tidskrift*, Vol. 65, Feb. 9, 1935, page 47. A new method for surface hardening developed in Germany. It is used for axles and similar pieces; the piece to be hardened is centered in a lathe and heated with a regular welding torch. As the piece is turned it is then cooled with a spray of water. The entire procedure, which is completely automatic, requires about 15 min. The hardness obtained is comparable to that resulting from case-hardening, but the surface layer is thicker (2-3 mm.) without any sharp dividing line between this layer and the softer core. As the piece is not heated through during the process no appreciable deformation takes place. The surface layer has no tendency to flake off, and on account of its thickness it may be ground and polished without detrimental effect. BHS (5b)

Tempering Martensite (Sul rinvenimento della martensite). V. MONTORO. *La Metallurgia Italiana*, Vol. 27, Jan. 1935, pages 24-26. A study of the structure of partially tempered martensite using the technique of Debye and Scherrer, has been made. The lattice is tetragonal, but at 100° C. changes to cubic in 14 hours. At higher temperatures the change is more rapid, thus, at 170° C. the change is complete in ½ hour. The spectrograph shows that the change is accompanied by a decrease in combined C. AWC (5b)

5c. Aging

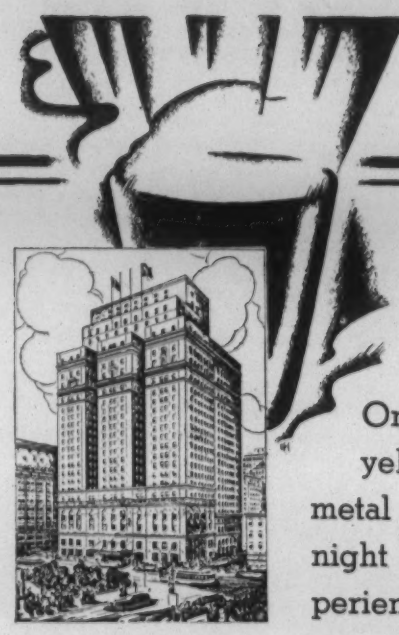
Testing Sheets for Blue Brittleness and Stability Against Changes Due to Aging. R. L. KENYON & R. S. BURNS. *Proceedings American Society for Testing Materials*, Vol. 34, Pt. II, 1934, pages 48-58. The authors have applied the principle that strain aging and blue brittleness of ferrous materials are but different manifestations of the same phenomenon and have developed a relatively rapid method of evaluating the aging properties of such material by determining the tensile strength at room temperature and at a temperature in the blue-brittle range. The apparatus used in the determination of the tensile properties of sheet material at elevated temperature (up to 600° F.) is described. The difference between the tensile strength at room temperature and that determined at 400° F. is correlated with the change in tensile properties of cold-rolled sheets due to an artificial aging treatment. Results show that as long as the tensile strength at 400° F. is not greater than at room temperature, the tensile strength and ductility of material cold-rolled 2% are practically stable against changes due to aging. The difference in tensile strength between room temperature and 400° F. is therefore used as a measure of the stability of the drawing properties of sheet steel. In using this criterion it is necessary to consider both return of stretcher straining, as indicated by the yield-point elongation and the constancy of the tensile strength and percentage of elongation. A minimum difference in tensile strength may then be adopted which will insure any desired degree of stability in drawing properties against changes due to aging. A large number of various materials have been tested according to this procedure and in all cases the authors report it has been possible to predict whether the material would age after cold rolling. VVK (5c)

5d. Malleableizing

Accelerated Annealing of Black Core Malleable Cast Iron (Le Recuit accéléré des Fontes malléables à coeur noire). TRY-CHALONS. *Revue de Fonderie Moderne*, Vol. 29, Jan. 10, 1935, pages 4-6. Supplementing his previous discussions on this subject (see *Revue Fonderie Moderne*, Nov. 25, 1934, page 328) the various phases of the malleablizing process are treated on the basis of the results obtained by Olson on accelerated malleablizing (see *Foundry*, Oct. 1934, page 49). Ha (5d)

5e. Carburizing

Selecting the Proper Hardening Treatment. H. W. MCQUAID. *Metal Progress*, Vol. 27, Mar. 1935, pages 25-30. Discusses recent developments in the heat treatment of carburizing steel. A normalizing treatment for high alloy steels or those containing any appreciable Mn or Mo is to heat well above the upper critical, cool rapidly to 1200° F., then very slowly to 500° F. and then quench directly from the carburizing box for wear resistance such as gears. Use of fine grained steels makes this direct quench entirely feasible and gives a microstructure and file hardness that results in best service results. Summary is made of some of recently reported findings on carburizing practice and material selection. WLC (5e)



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Changes in the Microstructure of Beryllium-Copper Alloys Due to Age Hardening.
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5f. Nitriding

1 — **Nitriding Characteristics of Cr-Mo-V Steels. An Aluminum-Free Series of Nitriding Steels.** JEROME STRAUSS & W. E. MAHIN. *Metals & Alloys*, Vol. 6, Mar. 1935, pages 59-62. Five steels with Cr 1.21%-5.70% with Mo about 0.50% and V about 0.20% have been studied as to their nitriding characteristics. Cr is found to have interesting effects upon the maximum hardness of the surface and the depth of this hardness. By variation between 1 and 6% Cr a variety of characteristics can be obtained. 2.65% Cr steel maintains its high hardness with excellent toughness even with tempering above the nitriding temperature. WLC (5f)

2 — **Nitriding of Steels and Cast Irons (La Nitruration des Aciers et des Fontes).** M. BABINET. *Science et Industrie (Métaux et Machines)*, Vol. 19, Jan. 1935, pages 13-17. First part gives review on scientific researches which led to nitriding process. 2d part deals with the process itself. 3d part is devoted to the study of properties of nitrided steel which are (1) Hardness : 1,150-1,200 Brinell for superficial layer. (2) Freedom from deformation during heating of the parts at 500° C. (3) Preservation of hardness when the nitrided parts are heated up to 500° C. (4) Resistance to oxidation and corrosion. (5) Resistance to wear and good bearing qualities. (6) Resistance to fatigue. Next part discusses composition of nitriding steels typical composition being : Cr 1.5-2, Al about 1 with small quantity of Mo which improves mechanical properties and suppresses brittleness due to long heating at 500° C. Recently 2 new kinds of steels have been developed: (1) Cr-Si-Mo steel, (2) austenitic steels. Applications of nitriding steels are reviewed. Nitriding of cast Fe is discussed. Last section briefly discusses hypothesis advanced to explain hardening by nitriding. FR (5f)

3 —

4 — **Rapid Nitriding of Steel.** J. E. KONTOROVICH. *Metal Progress*, Vol. 27, Feb. 1935, pages 43, 52. A 3 stage nitriding process is described requiring from 1/2 to 1/3 the time usually required. Stages are at 930° F., 1100-1200° F. and 930° F. and in that order. WLC (5f)

5 — **Hardening Cylinder Liners.** J. DUMMELOW. *Automobile Engineer*, Vol. 25, Jan. 1935, pages 7-9. A good material for cylinder liners with little wear and corrosion is found to be Al alloy steel quenched in oil at 900° C. and tempered at 650°-750° C. When nitriding this material all corners should be rounded off as much as possible to avoid breaking off hard edges; nitriding is carried out at 500°-620° in anhydrous ammonia gas. The parts are hardened in the finish-machined condition with no necessity for further heat-treatment. Tables of mechanical properties and curves of depth of penetration of hardness by nitriding are given, equipment and service results described. Ha (5f)

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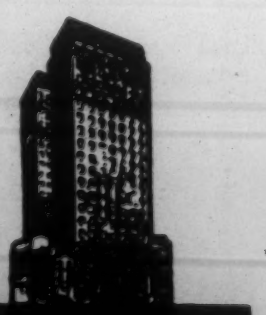

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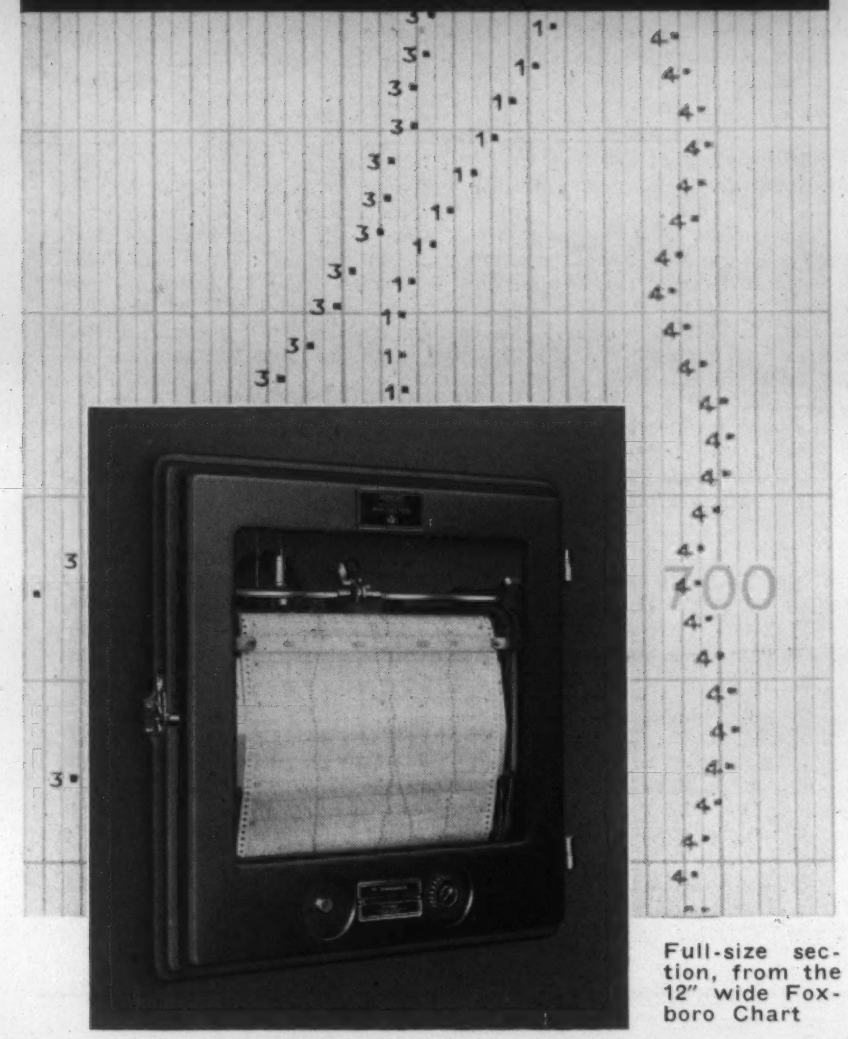

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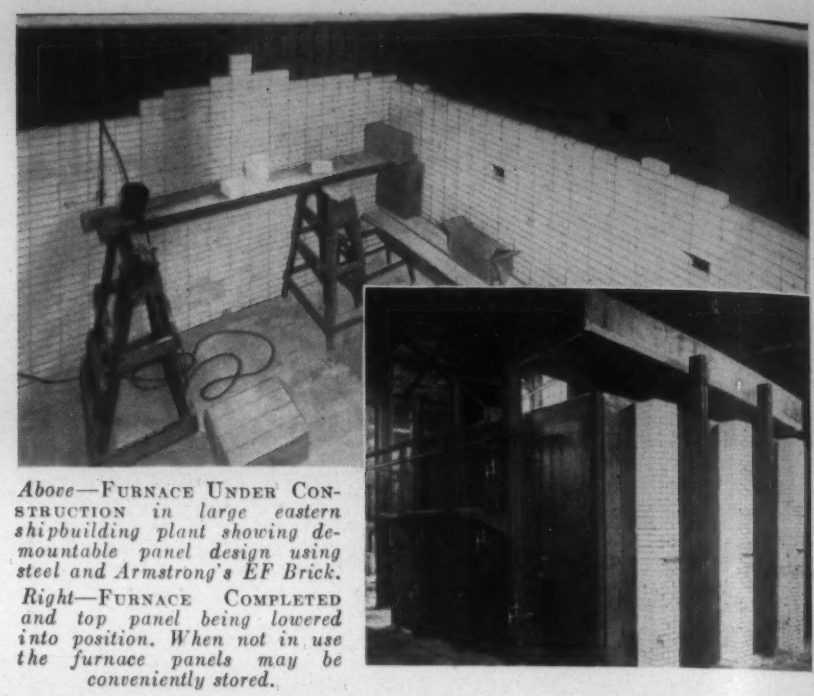

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6. FURNACES, REFRACTORIES AND FUELS

M. H. MAWHINNEY, SECTION EDITOR

High Temperature Insulation for Industrial Furnaces. N. ALLEN HUMPHREY. *Heat Treating & Forging*, Vol. 20, Oct. 1934, pages 509-511; Nov. 1934, pages 559-562; Dec. 1934, pages 612-616. Aim is to provide designers and users of industrial and steel-plant furnaces with an easy means of determining the kind and thickness of insulation that will be the most economical for the conditions. Discusses calculation of insulating values, heat losses, and temperature gradients; analyzes what constitutes the most economical thickness of insulation; and shows how this economical thickness can be calculated for the various conditions encountered in actual practice. Includes curves, tables, and examples. MS (6)

Recent Trends in Blast-furnace Operation and Design. B. J. HARLAN. *Mining & Metallurgy*, Vol. 15, Sept. 1934, pages 375-378. Trend in both design and operation of blast furnace has emphasized the necessity of producing pig Fe at lowest possible cost. Large furnaces are very flexible, able to produce daily tonnage between 500 and 1000 tons or more. Blast furnace gas must be cleaned to 0.02 grains/cu. ft. or less for use in modern stoves, coke oven regenerators, mill soaking pits and heating furnaces. Present trend may be summarized as follows: 1) Big furnaces; 2) Large stock-line areas; 3)Well cleaned gas; 4) Efficient hot stoves; 5) Moderate blowing; 6) Sized raw materials and 7) High hot-blast temperatures. VSP (6)

Performance of Open-Joint Checkers in Blast Furnace Hot Stove. M. K. MELLOTT. *Iron Age*, Vol. 134, Dec. 20, 1934, pages 26-27. **New Checker Brick Increases Hot Blast Stove Efficiency.** *Steel*, Vol. 95, Dec. 10, 1934, pages 49-51. Gives results of performance of open-joint checkers installed in a blast furnace hot blast stove in 1933. The open joint checker was developed by William M. Bailey Co., Pittsburgh. Includes a gas temperature chart showing high absorption of heat by checkers. VSP + MS (6)

Electric Heat Treatment of Light Metals (Das elektrische Anlassen und Vergüten von Leichtmetallen). E. FR. RUSS. *Metallwirtschaft*, Vol. 13, Dec. 28, 1934, pages 931-933. Due to the necessity for close temperature control and the high latent heat of Al alloys, electric furnaces with properly designed air circulating equipment are highly desirable. Three types of furnaces for this purpose are described. CEM (6)

A Portable Babbitt Pot. H. K. SELLICK. *Metals & Alloys*, Vol. 6, Feb. 1935, page 52. Describes portable babbitt melting pot and gives production data. WLC (6)

Bright Annealing at Linderme Tube Company. E. LINDERME. *Heat Treating & Forging*, Vol. 20, Dec. 1934, pages 605-606. Special continuous controlled atmosphere furnace is used for bright annealing coiled and straight Cu tubing. Work is conveyed on an alloy mesh belt. Heating zone is 9 ft. 6 in. long and has an alloy muffle. Cooling zone is 19 ft. long with a steel muffle. There is a H_2O-cooled jacket on the cooling section using about 200 gal. H_2O/hour, enabling work to be discharged at 200° F. Work is heated quickly to operating temperature of 900°-1200° F. by 16 tunnel-type burners located in the side walls and firing above and below the muffle. Atmosphere is provided by partial combustion of gas. Capacity is 600 lbs./hour. Recent test showed a consumption of 0.597 ft.^{3} of 1000 B.t.u. natural gas/lb. gross work treated at operating temperature of 1200° F. MS (6)

Time Required for Heating Steel. J. D. KELLER. *Heat Treating & Forging*, Vol. 20, Dec. 1934, pages 586-590. Describes methods for calculating the time required to heat rounds or cylinders of various diameters in furnaces at various temperatures. Heating process is divided into 5 separate stages, just as for flat plates (see *Metals & Alloys*, Vol. 5, Apr. 1934, page MA 138; Vol. 6, Mar. 1935, page MA 104). Compares results of calculations with available test results. Presents chart for reading directly the time required for heating mild steel rounds up to 12″ in diam. at furnace temperatures of 1300°-2400° F. Bars are assumed to be at least 3 times as long as their diam. and exposed to radiation from all sides. Radiation coefficient is taken as 60% of that of the ideal black body. Time required for heating is less than half as long as that for a plate of thickness equal to the diam. of the round, heated from both sides. MS (6)

Effect of Variations in the Alumina-Silica Ratio in Fused Refractory Materials Upon Resistance to Metal Oxides. CHARLES MCMULLEN, A. A. TURNER & G. J. EASTER. *Journal American Ceramic Society*, Vol. 18, Jan. 1935, pages 30-33. Furnaces for melting high tensile cast iron and non-ferrous metals require refractory linings which will not affect properties of the metal due to reaction with metal oxides. Silicon carbide refractory shapes are being used for door frames lining because of high resistance to thermal shock but are not always satisfactory for contact with molten metal or slag. Electrically fused silica-alumina refractories as monolithic, rammed lining are giving satisfactory service. Tests made on reaction of non-ferrous and ferrous oxides with the refractory and the bond material separately. Refractories with 80% alumina, 20% silica showed least attack with iron. With brass, alumina gave least attack but the 80-20 mixture also gave good results. WB (6)

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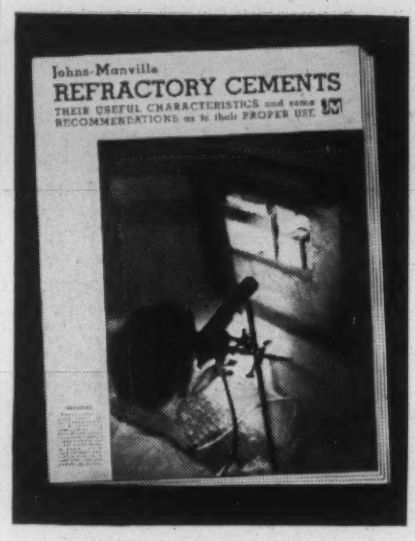

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1 **New Studies on the Losses in a Roll and Pusher Type Furnace (Neuere Untersuchungen über den Ofenabbrand an Roll-und Stossöfen).** F. WESEMANN. *Stahl und Eisen*, Vol. 55, Jan. 10, 1935, pages 33-38. A theoretical discussion of the relation of furnace losses to the surface and weight of the ingots or billets, the gas consumption, temperature and time at temperature, and furnace design. SE (6)

— **Induction Furnace Without Movement in the Molten Charge Designed for Melting Light Alloys (Der Induktionofen ohne Badbewegung beispielweise zum Schmelzen von Leichtmetallen).** E. FR. RUSS. *Zeitschrift für Physik*, Vol. 93, Jan. 4, 1935, pages 220-226. Description of induction furnace is given which has a dividing wall built in the hearth to eliminate convection currents and subsequent movement of the molten bath. This condition is especially designed for Al and light alloys. FHC (6)

2 **Factors Influencing the Properties of Semi-Coke.** JOHN ROBERTS. *Colliery Engineering*, Vol. 11, Nov. 1934, pages 379-382. Discusses the critical temperature, ignition temperature, influence of H on ignition point, influence of graphitic C, electrical conductivity of coke, influence of the ingredients in coals and coal blends. Kz (6)

— **Small Cast Thorium Oxide Crucibles.** H. K. RICHARDSON. *American Ceramic Society Journal*, Vol. 18, Feb. 1935, pages 65-69. Thoria crucibles used for melting Th, U, Zr without attack of the crucible by molten metal. Good ceramic practice used in preparing crucibles, consists of preparing slip with cryolite, casting and firing at 1885°C. in special gas furnace. Zr oxide added makes crucible
3 easier to prepare. Crucibles used in vacuum-induction furnace to melt pure metals up to 2300°C. Crucibles are mechanically strong with thin walls. Same casting procedure can be used to make crucibles from Mo and W metallic powders. WB (6)

— **Insulating Refractories.** W. M. HEPBURN. *Journal American Ceramic Society*, Vol. 18, Jan. 1935, pages 13-17. Insulating refractory brick has been successfully used in furnace construction and is now being applied to air-heaters, car-bottom furnaces, walking-beam bright annealing furnaces and glass leers, and bell type and wire patenting furnaces. Properties of this brick suggest use in
4 heat treating operations and vitreous enamelling furnaces, but do not warrant use as yet in open hearths, soaking pits and billet heaters. Use in sheet and pair furnaces is doubtful so far, due to danger of dusting from the arch. The properties of the brick are discussed and shown in curves and tables. Their advantages are that thinner and lighter furnace walls are possible thus allowing a lighter shell for portable furnaces also for a given rate of firing the time required to come to temperature is less by 25 to 35%, and heat storage is reduced. WB (6)

— **Young's Modulus of Elasticity at Several Temperatures for Some Refractories of Varying Silica Content.** RAYMOND A. HEINDL & WILLIAM PENDERGAST. *Bureau of Standards Journal of Research*, Vol. 13, Dec. 1934, pages 851-
5 862. Determinations of Young's modulus of elasticity of 10 brands of fire-clay bricks (ranging in silica content from 48-52%), 2 brands of silica bricks, and an 80% alumina fire brick, were made at room temperature, 100°, 200°, 400°, 500°, 600°, and 800° C. In a few cases a few determinations were made at 300°, 700°, and 900° C. Six samples were tested through room temperature
— regions of crystalline silica inversions at intervals of less than 100° C. The data show that the modulus of elasticity is affected greatly by the total silica content, modified by the form of the crystalline silica present and by the temperature. A general relation was found between modulus of elasticity, total silica, and linear
6 thermal expansion. WAT (6)

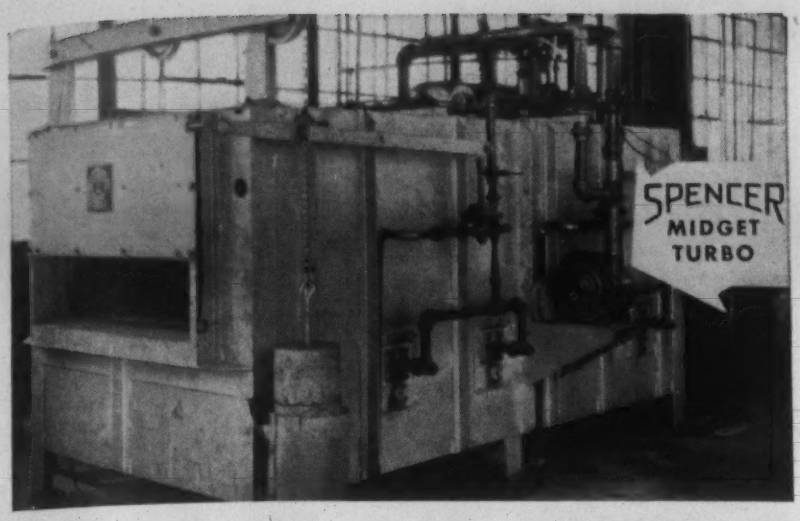
— **Comparison of Used Silica Brick from Insulated and Uninsulated Basic Open-Hearth Roofs.** FRED A. HARVEY. *Journal American Ceramic Society*, Vol. 18, Mar. 1935, pages 86-94. Samples of silica brick from the roofs of two basic open-hearth furnaces were examined, those from the insulated roof lasted 364 heats and those from the uninsulated roof lasted 346 heats. They were examined and compared by chemical and petrographic methods. A brief review of the literature on silica brick in uninsulated open-hearth furnaces is
7 given. WB (6)

— **Blast-Furnace Slag as Insulating Material.** W. TRINKS. *Blast Furnace & Steel Plant*, Vol. 22, Dec. 1934, page 707. Blast-furnace slag, in the granulated form, or as slag-wool, or as plastic, is a good insulating material around the steel-works during times of depression. At about 700° F., granulated slag and slag-wool have a conductivity 1/6 that of fire-brick at the same temperature. However, mass is very much less and therefore little heat is stored while being heated up. Slag-wool becomes plastic at about 1400° F. and in this condition attacks SiO_2 brick. It is, therefore, inadvisable to put blast-furnace slag-wool directly on the roof of a high-temperature furnace. On side walks,
8 it is commonly used in a mixture with 5% lime and enough molasses to make a binder. Blast-furnace slag is very corrosive if either red-hot or wet, due probably to the S content. MS (6)

— **Insulating Firebrick Applications.** M. J. TERMAN. *Heat Treating & Forging*, Vol. 20, Aug. 1934, pages 403-405, 407. Paper read before the Association of Iron and Steel Electrical Engineers. See *Metals & Alloys*, Vol. 6, Feb. 1935, page MA 56. MS (6)

9 **Cork in Fire Bricks.** T. E. WOOD. *Scientific American*, Vol. 152, Apr. 1935, page 201. Pulverized, diatomaceous earth is mixed with ground cork and clay, molded to shape and fired in kiln. The cork is burned out and leaves additional air cells to increase insulating qualities. After filling the molds they are subjected to high pressure in press and shapes are turned out of molds mechanically, onto conveyor belt. All refractory shapes can be made by the
— process. WB (6)

10 **Apparatus for Measuring the Thermal Conductivity of Refractories at High Temperatures.** J. L. FINCK. *Journal American Ceramic Society*, Vol. 18, Jan. 1935, pages 6-12. Description and photographs of the apparatus for tests on small samples such as brick are given. Apparent rather than true states of thermal equilibrium are said to cause discrepancies up to 50% and 100% in results of heat conductivity measurements. With normal heat flow and true thermal equilibrium the results check within 10% for fire brick and 5 or 6% with insulating brick. Test could be carried to 2000° F. with the apparatus. WB (6)



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Furnaces for Making Knee Action Springs. J. B. Nealey. *Heat Treating & Forging*, Vol. 21, Jan. 1935, pages 37-39. Same as *Industrial Heating*, Nov. 1934, pages 105-110. See "Heat-Treatment of Springs for Knee Action Mechanism," *Metals & Alloys*, Vol. 6, Jan. 1935, page MA 10. MS (6)

Light Weight, High Strength Still Refractory Trend. *Steel*, Vol. 96, Jan. 7, 1935, pages 164, 282-285. Reviews developments in the refractories industry during 1934. MS (6)

Refractories in 1934. *Blast Furnace & Steel Plant*, Vol. 23, Jan. 1935, pages 41-43; *Heat Treating & Forging*, Vol. 21, Jan. 1935, pages 42-44. Discusses developments during the year. Includes contributions by G. G. Coolidge, L. C. Hewitt, and R. P. Heuer. MS (6)

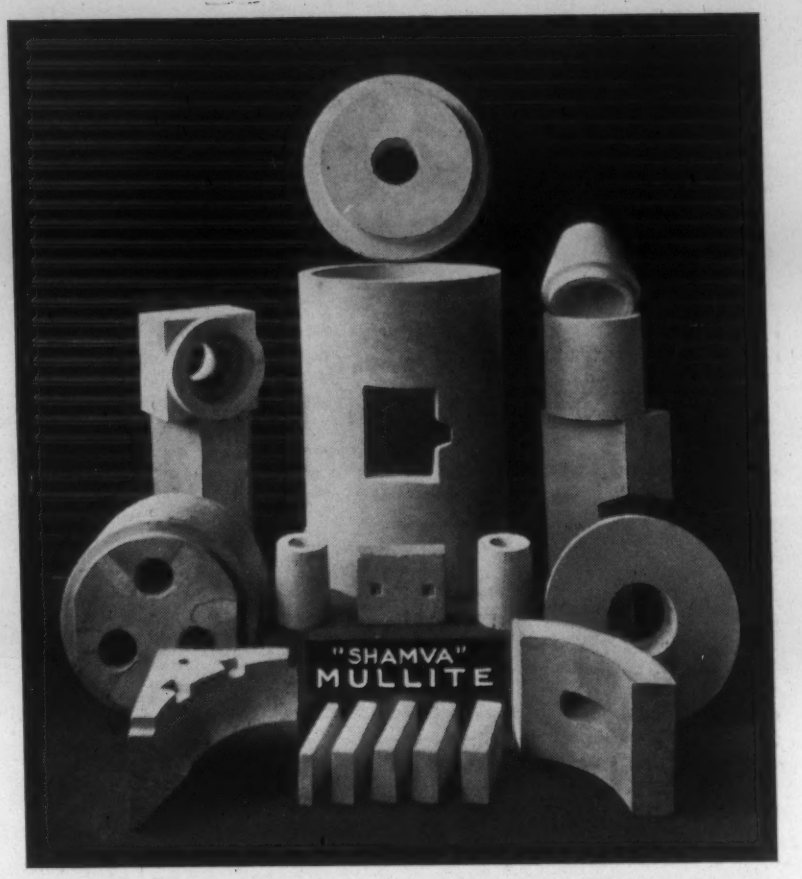
Reactions in Cupola Refractories. R. E. Aptekar. *Foundry*, Vol. 63, Sept. 1934, pages 26-28, 67. From a paper presented at the foundry short course of the Mechanical Engineering Dept. of the Michigan State College of Agriculture and Applied Sciences. Gives information on the best available data toward a practical and technical interpretation of the properties and behavior of cupola refractories. Variations in the 4 zones of cupola place definite demands on refractories. Unless proper refractories are used in each zone cost of operation will be high due to constant repairs. Includes tables giving analyses of acid material, different clays and composition of clays after burning. VSP (6)

Care of Cupola Refractories. C. E. Bales. *Foundry*, Vol. 63, Jan. 1935, pages 44, 48. Abstract of an article in technical bulletin of the American Refractories Institute. Proper selection of high grade cupola blocks and attention to operating details mean longer service, more efficient cupola operation and lower maintenance costs. VSP (6)

Some Notes on the Use of Silica Refractories in Open-Hearth Furnaces. E. Craddock & E. M. Myers. *Iron & Coal Trades Review*, Vol. 130, Feb. 8, 1935, page 251. Properties required of silica bricks are resistance to high temperatures, resistance to spalling, and resistance to slag attack. The normal refractoriness of silica bricks is 1710° C. Chemical composition and the various modifications are explained. Bricks with predominant quartz content are less susceptible to sudden heat changes while those with predominant tridymite content are less liable to spalling. Particular applications for open-hearth furnaces are discussed. Ha (6)

Oven and Dryer Construction. C. F. Mayer. *Industrial Heating*, Vol. 2, Mar. 1935, pages 149-151. Describes a furnace with insulated steel panel walls consisting of steel plates between which a heat insulation with slots is placed so that the path of the heat from one side to the other is considerably lengthened with resulting reduction in heat losses. Ha (6)

Heat Treatment of Spring Leaves. W. C. Owen. *Metal Progress*, Vol. 27, Mar. 1935, pages 51-55, 64. Describes equipment for treatment of automobile leaf springs. WLC (6)



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7. JOINING

Welding Is More Generally Accepted in All Fields. *Steel*, Vol. 96, Jan. 7, 1935, pages 157, 270-274. Survey of progress made in welding during 1934, with brief attention to advances made in riveting. MS (7)

Working of Monel Metal—Joining Methods (Le Travail du Métal Monel—Méthodes d'Assemblage). *Science et Industrie (Métaux et Machines)*, Vol. 18, Dec. 1934, pages 353-354. Methods for which concise rules are given are: (A) Fusion Welding, (1) torch welding, (2) arc welding, (3) spot welding, (4) automatic continuous spot welding on overlapped joints (for thin plates), (B) soft soldering, (C) Ag soldering, (D) brazing. FR (7)

Note on Frictional Resistance of Steel and Brass in Shrink Fits. W. H. Swanger. *Proceedings American Society for Testing Materials*, Vol. 34, Pt. II, 1934, pages 165-171, discussion pages 172-175. The making of shrink fits by refrigerating the inner member offers an easily accomplished alternative when the converse method of expanding the outer member by heat is not practicable or permissible. This paper presents data on the resistance to axial slip developed between cylindrical rings 1″ long and 1″ in internal diameter assembled on pins which at room temperature were about 0.0015″ larger in diameter. Prior to assembly the pins were contracted by cooling to —80° C. in a bath of acetone containing dry ice. Three combinations of material were used: namely, a brass ring on a brass pin; a steel ring on a brass pin; and a steel ring on a steel pin. The force necessary to cause initial slip is probably largely dependent upon the amount of "over-size" of the inner member. Seizing did not occur until relative motion had taken place between the 2 contacting surfaces. After seizing has occurred, the force necessary to continue the separation of the fitted parts is very much increased. Brass on brass showed no appreciable visible seizing; steel on brass showed some seizing with scoring of the brass and steel on steel seized badly. VVK (7)

7a. Soldering & Brazing

C. H. CHATFIELD, SECTION EDITOR

Brazing Bronze Lamp Posts. A. J. T. Eyles *Electrical Review*, Vol. 116, Jan. 11, 1935, page 52. Brazing with spelter was first tried for joining bronze castings, but was unsuccessful. Strong neat joints were made with "Sil-Fos." MS (7a)

Saving of Soldering Tin by Use of New Alloys and other Processes (Einsparung von Lötzinn durch neue Legierungen und andere Verfahren). E. Lueder. *Zeitschrift Verein deutscher Ingenieure*, Vol. 79, Jan. 26, 1935, pages 100-103. Sn being a material which has to be imported into Germany in large amounts experiments were made to repiace it by cheaper, domestic metals or by other processes in joining metals. Zn and Cd with Pb are used as solders especially if there is no great demand on the strength of the union, e.g. 85-90% Pb, 7-10% Cd, 1-5% Sn, or 16% Zn, 84% Cd for higher strengths. Replacing of soldering by welding and the different welding processes and procedures used for this purpose are discussed. Ha (7a)

The Navy's Soldered Fittings. Mason S. Noyes. *Journal American Society Naval Engineers*, Vol. 47, Feb. 1935, pages 57-74. Tests made on brazed and soldered fittings for non-ferrous pipe are reported. Purpose of the tests was the setting up of specifications for the solder, braze and the mechanical features of the joint. Tables are given for the compositions of various hard and soft solders with Cd, Ag, Cu, Pb, and Sn base. The present program involving the Navy's soldered fittings as applied to pipe systems is as follows: (a) Services and solders. Low pressure steam, compressed air and lubricating oil: Cu-Ag brazing solder required throughout. Fresh water and sea-water: Sn-Pb solder throughout. (b) Temperatures and pressures. 425° F. max. for Cu-Ag brazing solder joints; 150° F. max. for Sn-Pb joints. 200 lbs./in.² gage pressure max. throughout for Cu-Ag and 100 lbs./in.² for Sn-Pb joints. (c) Tubing. Seamless, for all services except sea-water; Cu-Ni alloy seamless for sea-water. (d) Fittings. Composition M or N-r (Navy). Union and all-solder types. Hole and groove (Navy) type of joint. (e) The intent of the study is to supersede all pipe threaded joints, insofar as possible. The function of the flux from the Navy's standpoint is to perform three services, it must clean the surfaces to be soldered, protect from further oxidation and give an unmistakable signal that the surfaces are at or near the correct soldering temperature. WB (7a)

7b. Welding & Cutting

Shot Weld—A Closely Controlled Welding Process. W. Spraragen. *Iron Age*, Vol. 134, Sept. 27, 1934, pages 18-21. Process is a high speed spot welding according to a new method which produces in the material certain desirable metallurgical and physical characteristics. As applied to austenitic stainless steel it produces stroong ductile welds having good fatigue values, leaving the structure free from carbide precipitation. The time cycle of shot weld varies from ½ to 18 cycles of a 60-cycle current, depending on thickness of material and size of spots. In order that spot represents a balance in strength between its shear value and strength necessary to tear out the spot, a diam. of electrode of 4 times the thickness of plate is used. Shearing strength is determined by pulling a specimen and ductility by a twist test. Weld penetration is determined by microscopic examination of etched section. Through use of shot welding of stainless steel it is possible to build a car of wt. of 250 lb. per passenger. Includes table giving current requirements for different gage materials. VSP (7b)

Design and Manufacture of Welded Steel Fabrications. H. W. Hawkins. *Mechanical World & Engineering Record*, Vol. 96, Sept. 28, 1934, pages 294-295; Oct. 5, 1934, pages 315-317. See *Metals & Alloys*, Vol. 5, May 1934, page MA 200. Kz (7b)

Modern Three Sheet Seams (Moderne Dreiblechnähte). Hans Melhardt. *Autogen Schweisser*, Vol. 7, Nov. 1934, pages 145-149; Dec. 1934, pages 162-165. See *Metals & Alloys*, Vol. 5, Dec. 1934, page MA 570. Kz (7b)

2 **Arc Welding of Aluminium.** *Engineer*, Vol. 158, Nov. 23, 1934, page 522. Barimar, Ltd., of London have developed a method of welding by using the electric arc which is proving superior to the use of the oxy-acetylene method. With the latter method, oxidation took place and the heat of the flame was rapidly transferred to other parts of the casting as Al is a good conductor of heat. The heat of the electric arc is more localized and the only oxygen liable to affect the metal is the small amount from the air. Direct current must be used to obtain the best results. LFM (7b)

3 **Fusion Welding of Pressure Vessels.** *Industrial Chemist*, Vol. 10, Nov. 1934, pages 424-425. A brief description of the methods employed by the Renfrew (England) works of Babcock and Wilcox, Ltd. The use of coated electrodes is discussed briefly. RAW (7b)

4 **Warping and Deformation of Welded-Steel Machinery Parts.** *Machinery*, London, Vol. 45, Jan. 10, 1935, pages 519-520. Lack of uniform cooling is cause of warping. The difference between calculated warping and actual warp is an estimate of the residual stress in member. Suggested remedies for warping are to tack the material to be welded to rigid frame during the operation, peening welds before laying the next bead, proper welding sequence to distribute the warp in such a way that successive welds counteract each other. The use of welding beads laid on the material to straighten a warp is discussed. WB (7b)

5 **Welding of Pressure Vessels.** *Journal of Commerce (Shipbuilding & Engineering Edition)*, Sept. 27, 1934, page 1. A discussion of the advance in mechanical control in welding operations deals with the developments which have taken place in the United States, Switzerland, and Britain, and shows that, both with regard to electric welding and oxyacetylene welding, the growth of mechanical control has been greatest in the first mentioned country. Progress in Britain has been slow but there is every indication that mechanical methods of control are now being rapidly developed and applied. JWD (7b)

6 **Steel Castings in Welded Structures.** R. H. Longbottom. *Machinery*, N. Y., Vol. 41, Feb. 1935, pages 340-341. The broad possibilities of the use of steel castings in conjunction with welded construction are pointed out. The complete structure is subject either to a full annealing at 1600°-1650° F. or to normalizing at 1200°-1250° F. according to facilities, shape, and duty of the welded structure. Plain C steels were found suitable for this purpose. Ha (7b)

7 **Arc Welding Ship Construction.** G. G. Landis. *Marine News*, Vol. 21, Jan. 1935, pages 41-42. Corrosion of welded joints found to be no greater than the adjoining metal of welded sheet. Use of the shielded arc increased tensile strength and ductility of welds. Advantages of welded construction possible only when ship is designed for welding. WB (7b)

8 **Welding.** Oscar Faber. *Welder*, Vol. 7, Dec. 1934, pages 386-387. Development of welding in connection with structural steel work and its advantages are discussed, the most important being complete absence of noise as compared with riveting, reduced cost, cleaner design and reduced space taken up by the steel work. The design must be adapted to this process. Ha (7b)

Notes on Problem of Stress Relieving Welded Parts. W. T. Davidson. *Steel*, Vol. 95, Dec. 10, 1934, pages 36, 60. Residual stress may be anything up to the yield-point of either weld-metal or parent metal. Stresses above the yield-point set up by weld contraction will be relieved by plastic flow of the material. At points of stress concentration from discontinuities or changes of contour in heavy welded structures, service loading, however, may involve stresses high enough to raise continually the yield-point, leading to premature failure. Stress relieving in a furnace at 1200° F., enables the welded assembly to withstand better such stresses. Stress relieving in a furnace is the most effective method and, in general, the cheapest. For welded steel machinery parts, it is carried out primarily to prevent "squirming" during machining. In some cases, mechanical stress relieving by peening is sufficient for practical purposes. In many cases, residual stress is not damaging to the safety or service life of the assembly. MS (7b)

9 **Fusion Welding as Applied to the Underground Heat Distributing Lines in Paris (La Soudure Autogène Appliquée aux Travaux de Chauffage Urbain de la Ville de Paris).** R. Dautel. *Revue de la Soudure Autogène*, Vol. 27, Jan. 1935, pages 5-9. Steam line must resist a pressure of 15 kg./mm.² whereas return water line has only to resist 4 kg./mm.² Initially electric welding had been visualized for most of the works but practice has shown that oxy-acetylene welding was more rapid and less expensive and is now resorted to in 85% of cases, electric welding being only used in straight line when tubes can be revolved on suitable rollers. Article describes and illustrates application of the joining methods. FR (7b)

10 **Application of Wear-Resistant Alloys to Steel Mill Equipment.** E. E. Le Van. *Iron Age*, Vol. 135, Jan. 10, 1935, pages 30-34. From a paper read before the annual meeting of the International Acetylene Association. Discusses the use of hard facing that is, welding on to wearing face a coating of a metal highly resistant to abrasion. Depending on types of hard facing alloy used and service to which it is subjected, they will outlast ordinary steel from 2 to 25 times. Selection of hard facing material is of great importance. Gives some typical steel mill applications. VSP (7b)

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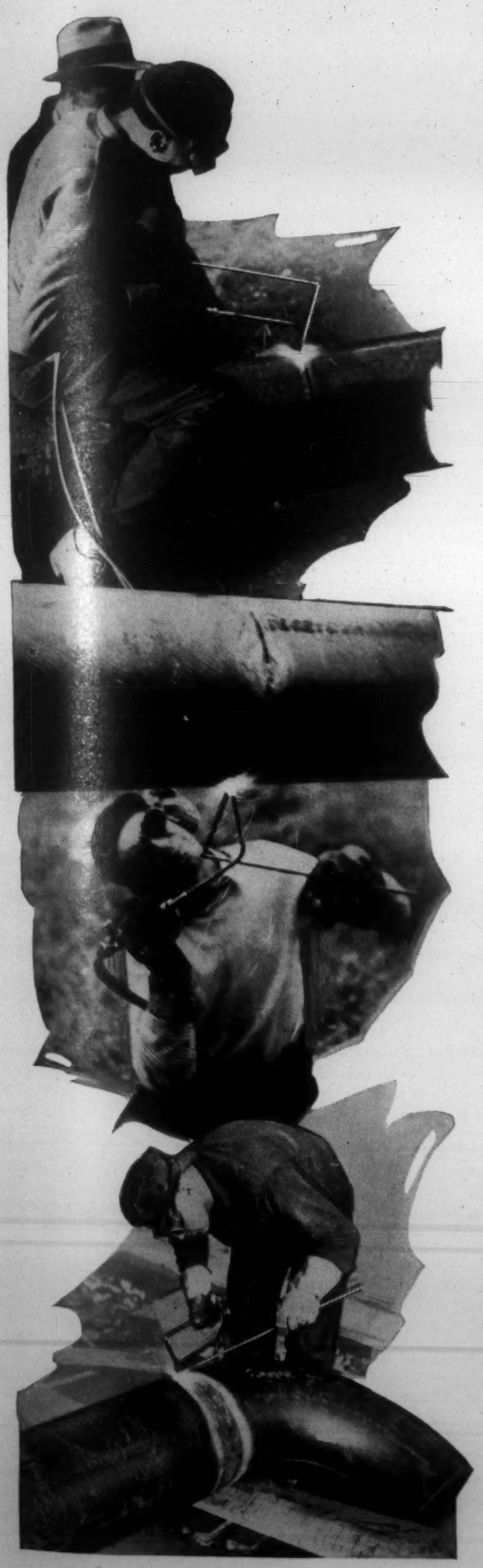

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Gases and Fumes Produced During Welding Operations (Gaz et Poussières Produits au Cours des Opérations de Soudure). A. LEROY. *Revue de la Soudure Autogène*, Vol. 26, Dec. 1934, page 13. Summarizes data collected by the "Office Central de l'Acetylene" for the health Department of the "Association des Industriels de France." In oxy-acetylene welding gases and fumes are due to (1) combustion of gases in the torch flame, (2) secondary reactions assisted by high temperature of oxy-acetylene flame, (3) physical and chemical transformations in metals and alloys, (4) physical and chemical transformations in fluxes used. Only item (3) must be kept in mind as having some importance for instance: oxide fumes in case of welding with brass. In electric welding, gases and fumes are due to (1) reaction of surrounding air components, (2) physical and chemical transformations of electrode metal, (3) physical and chemical transformations of electrode coatings. Items (2) and (3) must be considered. Very fine oxide dust is produced by the electrode metal. Although gases and fumes would not be deleterious welding operations should be carried out in well ventilated shops. FR (7b)

Welded vs. Cast Iron Jigs and Fixtures. GEORGE L. KLUTER. *Iron Age*, Vol. 135, Jan. 24, 1935, pages 18-21. Most important advantage of building jigs and fixtures by electric welding is the saving in initial cost of tools, which ranges from 20 to 30%. Equipment required is a pantograph type oxy-acetylene cutting machine, with radius attachment for circular work, electric arc welder and square surface plate with machined T-slots in both directions. Gives some specific cases. VSP (7b)

Substantial Developments in All Types of Welding. R. E. MILLER. *Iron Age*, Vol. 135, Jan. 3, 1935, pages 154-156, 159-160, 280-281. There has been substantial technical progress in all branches of welding and cutting. In arc welding the use of A.C. current process has increased, particularly in pressure vessel welding. Heavily coated electrodes that develop weld strength ranging from 85,000 to 100,000 lb./in.^{2} were developed. Various types of improved resistance welding machines have been put on the market. Some of the developments discussed are: A.C. arc process furthered by new electrodes; new electrodes meet wide variety of requirements; electric resistance welders highly developed; multi-flame head developed for gas welding torch; and substantial developments in all types of welding. VSP (7b)

New Records in Pipe-Line Welding. R. B. MILLER. *Gas Age Record*, Vol. 74, Oct. 20, 1934, pages 333-334, 336. Instances are given of rapid welding by the Lindeweld Process using a Multi-Flame blowpipe head. The process is based upon the use of an excess acetylene flame which produces a reducing atmosphere immediately surrounding the weld and maintains in the weld metal a carbon content substantially equal to that in the base metal, a backhand technique and a special welding rod. VVK (7b)

Hardening of Surfaces by Gas Welding (Le Durcissement des Surfaces par Rechargement). M. MICHAUD. *Revue de la Soudure Autogène*, Vol. 26, Dec. 1934, pages 2-8. Paper read at the XIth Congress of Acetylene and Fusion Welding in Rome, June 5-10, 1934. FR (7b)

Interesting Application of Double Side Oxy-Acetylene Welding (Une Application Intéressante de la Soudure Montante à Double Cordon). R. MESLIER. *Revue de la Soudure Autogène*, Vol. 27, Jan. 1935, pages 10-11. This method can be used for welding plates having up to 12 mm. thickness. Each of the 2 torches working simultaneously on each side of the joint must have a capacity of 30 liters C_2H_2/hr. Filler rods have a diameter of 2 mm. for 2-5 mm. plate thickness and 3 mm. for 6-12 mm. plate thickness. The method gives good results with 18-8 Cr-Ni steel. Article explains and illustrates manufacture of a gasometer made of Cu steel plate of 5 mm. thickness. Diameter of work is 6 meters and capacity 45 m.^{3} FR (7b)

Welded Chemical Equipment from Special Metals. EMERSON P. POSTE. *Industrial & Engineering Chemistry*, Vol. 27, Feb. 1935, pages 128-134. A review of the progress in welded chemical equipment, treated under the following headings: fusion-welded pressure vessels, low-C steel, alloy steel, clad steels, nonferrous metals and alloys, control tests, hydrostatic tests, and typical installations. Six photomicrographs of welded metal structures are shown. MEH (7b)

Absorption of Nitrogen by Iron Melted Under Electric Arc and the Iron-Nitrogen Diagram (Sur l'Absorption de l'Azote par Fusion du Fer à l'Arc et le Diagramme Fer-Azote). A. PORTEVIN & D. SÉFÉRIAN. *Revue de la Soudure Autogène*, Vol. 27, Jan. 1935, page 12. Note read before the "Académie des Sciences" on Dec. 26, 1934. FR (7b)

Mechanical Properties of Welds Studied by Small Test Pieces (Étude Micromécanique des Soudures). ALBERT PORTEVIN & PIERRE CHEVENARD. *Comptes Rendus*, Vol. 200, Jan. 21, 1935, pages 319-321. Results of mechanical tests on test pieces 1.5 mm. diam. cut from steel sheets (C 0.15, Cr 0.9, Mo 0.2) show the difference in physical properties in welded areas (1) next to the weld where melting occurs (2) beyond the weld where partial melting takes place and (3) where heating only occurs. For description of machine, see *Comptes Rendus*, Vol. 200, Jan. 14, 1935, pages 212-215. FHC (7b)

Fabricating Refrigerator Evaporators from 18-8. E. F. ROSS. *Steel*, Vol. 96, Jan. 21, 1935, pages 22-26. Describes practice of the General Electric Company in the forming and welding of evaporator units for monitor-top and lift-top units. Spot and seam welding is used. Cu equalizer tubes are attached to the stainless steel headers by Ag soldering. All welding machines are controlled by thyratron tubes to insure accurate weld timing. MS (7b)

Wide Sheets for Streamline Bodies Produced by Special Flash Welder. PETER W. FASSLER. *Iron Age*, Vol. 134, Sept. 20, 1934, pages 38-39. Describes the production of sheets for automobile bodies in widths up to 78 in. or more. Different methods have been tried in this country and abroad. Satisfactory welding of such sheets was accomplished by the flash method. An absolutely soft and clean weld was the goal. This was done through a slow weld. In making such welds, proper alignment is of great importance. Elkonite, a Cu-W alloy electrode was used which is able to withstand high clamping pressure without deformation. In finishing the weld the flash was removed by a Morton flash trimmer. VSP (7b)

Structural Welding Regulations and their Future Development. *Welder*, Vol. 7, Jan. 1935, pages 426-429. Mechanical testing of welds as regulated in different countries, design and structural details, workmanship and inspection are discussed and the various types of welded joints are illustrated. Ha (7b)

Bronze Welding (La Soudo-Brasure). *Soudure et Oxy-Coupage, Supplement to Revue de la Soudure Autogène*, Vol. 11, Oct. Dec. 1934, pages 236-237. Typical applications of the method, i. e. repair of broken cast Fe and bronze castings and building up of worn parts, are illustrated. FR (7b)

Specifications for Added Metals Used in Oxy-Acetylene Welding (Specifications Relatives aux Métaux d'Apport pour Soudure Oxy-Acétylénique). *Revue de la Soudure Autogène*, Vol. 27, Jan. 1935, pages 2-4. First part describes aim and application of specifications. Second part gives specifications dealing with added metal for welding steels. Properties are measured after melting of the metals. Metals are divided in 2 classes (1) Those which need only to be characterized by mechanical properties (tensile strength, elongation, impact resistance, Brinell hardness). (2) Those which must show special properties: Cu steels, corrosion resisting Cr-Ni steels, stainless Cr steels. Each kind of rod is marked with a conventional colouring. Third section explains testing conditions of added metals. FR (7b)

Largest Single Steel-Frame House Built by Arc Welding. *Iron Age*, Vol. 134, Dec. 27, 1934, pages 14-16. Describes the construction features of a steel frame house erected in Toledo. The house consists of 12 rooms, a total cubic content of 53,450 cu. ft. Fire proof construction, greater stiffness and rigidity as well as high speed of assembly, are provided for by the design of the arc welded steel frame. VSP (7b)

American Welding Society Marine Code for Welding and Gas Cutting. Part D. *American Welding Society Journal*, Vol. 14, Mar. 1935, pages 16-18. Rules for the fusion welding of hulls and hull plates. WB (7b)

Light-Weight, Streamlined Passenger Coaches Are Arc Welded. *Iron Age*, Vol. 134, Oct. 4, 1934, pages 36-37, 67. Describes the arc welding work on 52 new steel passenger coaches of Chicago, Milwaukee, St. Paul & Pacific R.R. Use of welding reduces weight 35%. Equipment used is made by Lincoln Electric Co. VSP (7b)

Arc-Welding in Ship Construction. DAVID ARNOTT. *Engineering*, Vol. 139, Jan. 18, 1935, pages 73-74. Abstract of a paper read before the Society of Naval Architects and Marine Engineers. Discusses methods of constructing a number of small arc-welded vessels, chiefly tank barges, built to the classification of the American Bureau of Shipping. VSP (7b)

Light Beam Indicator for Aluminum Resistance Welding. D. I. BOHN. *Metals & Alloys*, Vol. 6, Mar. 1935, page 70. Describes device for controlling time in spot welding of Al alloys. WLC (7b)

Metallurgy of Oxyacetylene Welding of Steel. J. H. CRITCHETT. *Welding Engineer*, Vol. 20, Feb. 1935, pages 21-24. The physical changes (expansion and contraction), metallurgical effects (crystallization), heat-treatment, and the effect of alloys and the chemical reactions of liquid steel with its surrounding materials, which all occur in the welding process, are discussed. Reactions in welding and in open-hearth practice are analogous. Ha (7b)

Production Methods Used on Welding for Construction Purposes. G. E. DEATHERAGE & J. B. LATTERNER. *Mill & Factory*, Vol. 15, Dec. 1934, pages 55-58. Paper read at the 35th Annual Convention, International Acetylene Association, Pittsburgh, Nov. 14, 15, and 16, 1934. Application of the oxy-acetylene process in piping work. Kz (7b)

Japanese Steel Equipment Fabricated by Arc Welding. A. F. DAVIS. *Iron Age*, Vol. 134, Sept. 20, 1934, pages 32-34. Describes the fabrication of steel mill drives by arc welding by the United Engineering & Foundry Co., Youngstown, in a quarter of the usual time. Welding equipment used was supplied by Lincoln Electric Co., Cleveland. VSP (7b)

Gas Welding Manganese Steel Develops Brittleness. JOHN HOWE HALL. *Steel*, Vol. 95, Dec. 10, 1934, page 42. Criticism of article in Aug. 6, 1934, issue. Heating of Mn steel castings by torch makes them brittle, and it is therefore necessary, in the case of gas welds of castings of any size, that entire casting be heat treated a second time. As very few establishments are equipped to heat treat castings, gas welding of any but small Mn steel castings is not to be recommended. MS (7b)

Welding of Heat-Resisting Steel Alloys (Das Schweissen der warmfesten und hitzebeständigen Stahllegierungen). H. SCHOTTKY. *Zeitschrift Verein deutscher Ingenieure*, Vol. 79, Jan. 12, 1935, pages 41-46. Several definitions are given: Creep strength (Warmfestigkeit) is the property to resist high mechanical stresses at elevated temperatures. Each metal has a temperature limit, below or above room temperature, at which the duration of the load affects the resistance and slow creeping starts. Creep strength is generally considerably improved, up to 550° C., by even slight alloying while heat resistance in chemical respect can only be increased gradually by additions of Si, Al and Cr, or Ni. The different groups of alloy steels are discussed. All these alloys can not be fire-welded; electric and fusion welding can be employed without deterioration of the properties. Adjustment of flames, testing of welds and some examples are described. Ha (7b)

Some Fundamentals of Spot Welding Especially of the Light Alloys. RAYMOND H. HOBROCK. *Metals & Alloys*, Vol. 6, Jan. 1935, pages 19-25; Feb. 1935, pages 41-45; Mar. 1935, pages 67-69. 14 references. Spot welding is said to result, like hammer welding, from recrystallization below melting temperature. This recrystallization is affected by deformation of the metal and recrystallization temperature. Strength and reliability of spot welds are discussed with respect to several factors such as mechanical and electrical construction of the welding machine, temperatures and deformation produced by the machine and some physical properties of materials being welded. WLC (7b)

Welding High-Pressure-High Temperature Steam Piping. SABIN CROCKER. *Heating, Piping & Air Conditioning*, Vol. 7, Feb. 1935, pages 81-84; Mar. 1935, pages 132-136. Part I. Stress relieving of welds by means of a ring collar which can be clamped around pipe weld, is the main part of the paper. The ring collar is a high-frequency induction furnace coil which is portable thus making possible heat treatment of pipe-welds in place. The purpose of stress relieving is two-fold. First, to heat the structure to a temperature sufficiently high to allow any locked-in stresses from welding to relieve themselves by creep. This could be accomplished in the neighborhood of 900° F. provided sufficient time were allowed at that temperature for creep to take place. The more practical range is 1100°-1200° F. because of more rapid creep. The second purpose is to take advantage of the drawing or tempering action existing in the latter range as commonly used in heat-treating alloy steel castings and in the partial annealing of quenched or cold worked forgings. This draw has been found to increase the ductility of electrically deposited weld metal as much as 50% in some cases and the impact resistance shows an increase of 10-15%. There probably is also an increase of fatigue resisting properties. The martensite and troostite structures are changed to sorbite. Part II. Creep of steel due to high pressure and temperature necessitates periodic tightening of bolts on flange-bolted steam lines. This is especially difficult when it is necessary to uncover the bolts in order to tighten them. The use of welded joints is considered a superior substitute for the flange-bolted line when they conform to the following specifications: (1) line welds to be of full strength variety made in position without the need for straps or other reenforcement and stress relieved in place for pipe sizes 2½" and larger, (2) valves to have welding ends, (3) manifolds to be fabricated from pipe with branch outlets reenforced where required in accordance with Boiler Code rules and stress relieved preferably in a furnace, (4) weld splatter inside the pipe to be avoided through the use of backing rings in pipes 2½" and larger where butt welds are employed and through the use of socket or sleeve welds in pipe 2" or smaller, (5) welding to be done by duly qualified welders, (6) all welded lines to be given a hydrostatic and hammer test after erection. The quality control of the welding is effected by graphical recording device which evaluates the consistency of the welder by measuring the ratio of arcing time to short circuiting time. A sample curve is given. WB (7b)

Soldering-Over of Auto Body Welds Eliminated by Proper Procedure. PETER W. FASSLER. *Iron Age*, Vol. 134, Nov. 15, 1934, pages 12-14, 69. Automobile body manufacturers here and abroad solder-over flash welding. Author states that with proper procedure in welding soldering can be eliminated. Most important detail in flash welding is the proper welding line with the proper tangents. By means of a die drawing explains the development of the proper welding line. VSP (7b)

Butt-welding Theory. P. W. FASSLER. *Welding Engineer*, Vol. 20, Feb. 1935, pages 26-28. Manner of calculating heat requirements, time and capacity of welding transformer is described; curves for determining best conditions for butt-welding are given. Ha (7b)

7c. Riveting

Age Hardening of Light-Metal Rivets (Das Vergüten von Leichtmetall-Nieten). A. VON ZEERLEDER. *Aluminium*, Vol. 17, Nov. 1934, pages 138-140. Rivets of age-hardening materials of the duralumin type (avional, aladur, bondur, ulminium and haddall) must be age hardened immediately before riveting since the rivet head can not be properly formed after the material has hardened. Rivets of the type of anticorodal, pantal, corrofestal, which harden only at higher temperatures can be stored in semi-hard condition and finished in that state without annealing. A few methods and annealing furnaces to heat treat the former type are described. Ha (7c)

Light-Metal Riveting (Aus der Praxis des Leichtmetall-Nietens). W. ZARGES. *Aluminium*, Vol. 17, Nov. 1934, pages 127-137; Dec. 1934, pages 177-188. While the carrying capacity of an Fe rivet depends on the friction resistance due to the shrinking of the rivet that of the cold-made light-metal rivet joint depends entirely on the shear resistance. The various rivet shapes, solid and hollow rivets, joining of materials with rivets of the same and of different material, calculation of carrying capacity, technique of riveting with regard to the properties of light metals are discussed and riveted joints are explained by drawings. 33 references. Ha (7c)

Hot Riveting of Hardenable Al Alloys (Warmnieten aushärtbarer Al-Legierungen). R. IRMANN. *Aluminium*, Vol. 17, Dec. 1934, pages 189-190. Rivets of more than 12 mm. diam. of hardenable Al alloys are difficult to rivet cold and are usually heated. It has been found, however, that this process reduces the strength of the duralumin considerably around the hole besides being very inconvenient so that it is recommended to use for large rivets over 12 mm. diam. either soft duralumin or more rivets of smaller diam. Ha (7c)

Light Metal Rivets (Leichtmetallnieten). K. GULER. *Zeitschrift für Metallkunde*, Vol. 26, Mar. 1934, pages 65-67; Apr. 1934, pages 90-91. March instalment discusses design of light alloy rivets. April instalment gives directions for determining shearing strength, tensile strength, elongation, ball hardness and impact strength and for determining proper solution heat treatment times and temperatures. See also *Metals & Alloys*, Vol. 5, June 1934, page MA 284. RFM (7c)

Notes on Dural Riveting. R. V. HITCHINSON. *American Machinist*, Vol. 78, Sept. 12, 1934, pages 638-639. What is going on inside a riveted joint during squeezing operation was studied on actual cases. As long as the forces are symmetrical along the rivet axis uniform stresses are exerted in the sheet; otherwise deformation may take place. The type of head has an influence on the force required to rivet and on the amount of swelling of the head. A formula for the effective force is given. Ha (7c)

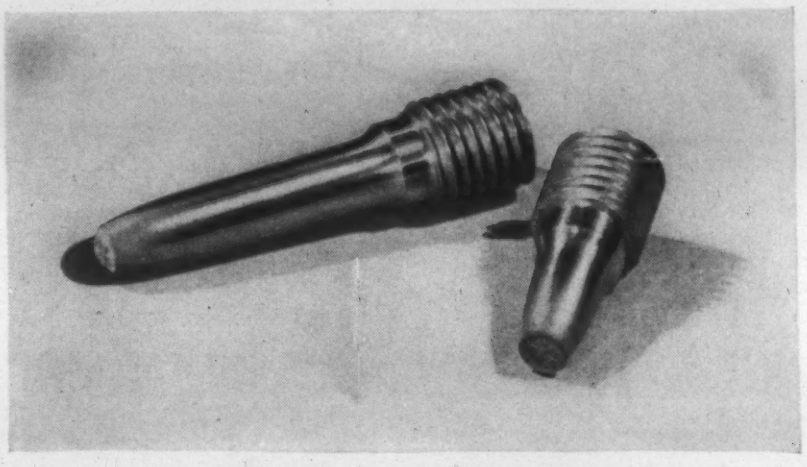
Thickness of Riveted Pipes for Hydraulic Pipe Lines. Selection of Type of Riveting (Epaisseur des Tuyaux Rivés pour Conduites Forcées. Détermination et Choix des Rivures). G. GILLES. *Arts-et-Métiers*, Vol. 85, Dec. 1933, pages 314-322. Possibilities of riveting are studied. FR (7c)

CARBON-MOLYBDENUM STEEL

Recently introduced steels containing small quantities of molybdenum are notable for their excellent tensile strengths and high creep strength, or resistance to slip between adjacent grains when stressed at high temperatures. The usual molybdenum content of such steels is .40% to .70%.

MUREX CARBON-MOLYBDENUM

WELD METAL



PHYSICAL PROPERTIES

Yield Point	55,000 p.s.i.	Elongation in 2 in.	34%
Ultimate Strength	73,000 p.s.i.	Reduction in Area	66.6%

CHEMICAL ANALYSIS

Carbon	.12%	Molybdenum	.48%
Silicon	.08%	Manganese	.64%

Phosphorus and Sulphur ... less than .035%

Murex Carbon-Molybdenum .50 Electrodes are used widely in welding piping for high-pressure and high temperature services. Rapid in operation, they can be depended on consistently to produce clean, sound deposits with physical properties equal in every respect to those of the metal being welded. In fact, the particular properties of the deposit depend to a great extent on the carbon, molybdenum and manganese contents of the parent metal. When welding high strength manganese-molybdenum steel, for example, the weld metal may develop tensile strengths as great as 97,000 lbs. per sq. in.

Murex Electrodes for welding alloy steels . . . including Cromansil, Cor-Ten, 2½% Nickel, .85% Nickel, 4% to 6% Chrome . . . have found wide acceptance throughout industry. All are standard Murex Electrodes and can be furnished promptly from stock.

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HEAVY MINERAL COATED ELECTRODES

8. FINISHING

H. S. RAWDON, SECTION EDITOR

Metal Surfaces Treated and Finished More Effectively. *Steel*, Vol. 96, Jan. 7, 1935, pages 148-149, 263. Reviews important advances made in 1934 in surface treatment of metals. MS (8)

The Year's Progress in Metal Finishing. HERBERT R. SIMONDS. *Iron Age*, Vol. 135, Jan. 10, 1935, pages 24-29. A major development in 1934 was the increased appreciation of the commercial significance of a good finish. Of great significance was the completion of exposure tests of plated coatings involving the exposure of 700 panels, the results of which have been summarized as useful specifications. The most important development in metal protection was the introduction of heavy Zn coating, according to one authority. In a review of plating progress Colin G. Fink points to a number of developments in corrosion protection. Important progress was made in pickling and burnishing. Enamels and lacquers were improved. Some of the European developments consist of (a) electrocleaning in combination with hot galvanizing, (b) spreading Al powder over Zn bath to prevent oxidation of Zn and to give galvanized products a silvery finish, (c) coloring Al with oxalic acid and (4) a German process for bright Ni plating. VSP (8)

How Attractive Finish Helps Metal Products Sales.—28. Some Practical Finishing Problems. HERBERT R. SIMONDS. *Iron Age*, Vol. 134, Nov. 22, 1934, pages 19-23. Describes practical experience in finishing various products such as; golf club heads, bolts and nuts, automobile coil springs, steel beer kegs and structural Al. VSP (8)

8a. Pickling

Surface Cracking of Steel Castings During Pickling. C. W. BRIGGS & R. A. GEZELIUS. *Metals & Alloys*, Vol. 6, Feb. 1935, pages 39-40. Data show that steel castings develop H_2 embrittlement in pickling. Though use of inhibitors, annealing before pickling and boiling water after pickling lower the tendency to embrittlement of the material, pickling should be avoided as method of cleaning whenever possible. Combination of internal tensile stresses and the action of acid appear to cause incipient cracks. WLC (8a)

Recent Investigations of the Pickling of Iron (Neuere Untersuchungen über das Beizen von Eisen). W. MACHU. *Korrosion und Metallschutz*, Vol. 10, Dec. 1934, pages 277-288. The different methods of pickling, i.e. removal of scale from Fe for various purposes of working, the nature of their action and that of inhibitors were investigated. Effect of the latter consists in a greater adsorption of the colloid by pure Fe than the scale; the covering layer contains about 50% pores. Resistance of the passivating layer against dissolving is increased in presence of gelatin. The capillary action of the layer retards the dissolving of Fe because it reduces the velocity of the ions of the pickling acid. Experiments are described in detail. Ha (8a)

8b. Cleaning, including Sand Blasting

The Cleaning of Metals. 6. Degreasing by Means of Organic Solvents. S. WERNICK. *Industrial Chemist*, Vol. 10, Dec. 1934, pages 479-481. The use of and properties of ethylene trichloride are given together with details of construction and operation of a small vapor-liquor plant. RAW (8b)

Bullard-Dunn Process Used to Clean Car Parts. *Iron Age*, Vol. 134, Dec. 20, 1934, pages 28-30. Description of installation for cleaning car parts at a Detroit automobile plant. The process is also used to clean metal parts internally such as motor oil lines. The process is claimed to be cheaper and the quality of the work better than that of wire brushing. VSP (8b)

8c. Polishing & Grinding

Grinding Detachable Chain Links. EDWIN BREMER. *Abrasive Industry*, Vol. 16, Feb. 1935, pages 6-8. Malleable cast-iron parts are finished for assembly by abrasion method. Protrusions on cast white iron links are removed by grinding while in the hard state because its brittleness shortens grinding time after which they are heat treated to produce tough malleable iron. WB (8c)

Surface Finish and How It Can Be Measured and Specified. E. J. ABBOTT. *S. A. E. Journal*, Vol. 36, Mar. 1935, pages 112-116; *Iron Age*, Vol. 135, Jan. 31, 1935, pages 23-26. Profilograph records are shown in which size and shape of surface irregularities can be measured in inch units. Surface finish cannot be expressed by a single number because size, shape and range of size and shape of profiles differ with various operations. Examination of ¼" of the surface with profilograph is sufficient, for evaluating most surfaces while fine finish requires still less than ¼". The actual contour of the surface is magnified many times on the photographic record and the magnification can be controlled within a large range. To illustrate the advantage of the profilograph over other methods for determining roughness, several records are shown for surfaces finished by different methods. WB + VSP (8c)

Surface and Shape Characteristics of Cylinder Bores. KIKKE W. CONNOR. *S. A. E. Journal*, Vol. 36, Mar. 1935, pages 93-111. Outline of methods for finishing cylinder walls with honing machines and for measuring of wall roughness by means of profilograph instrument. Wear of cylinder wall is discussed for automotive and Diesel service. Profilograph is essentially a diamond-point probe to which a small mirror is attached by means of which a light beam is reflected to produce a photographic record of surface contour as the probe is moved. Precautions necessary to observe in reboring cylinders to prevent misalignment due to head strains and warpage are pointed out with several examples of correct alignment produced by modern technique. WB (8c)

Grinding Stainless Steel Welds. E. P. GRISMER. *Abrasive Industry*, Vol. 16, Feb. 1935, pages 9-10. **Grinding Welds in Stainless Steel Demands Special Care.** *Steel*, Vol. 95, Dec. 24, 1934, pages 30-32. A flexible-shaft grinding wheel is generally necessary because the welded structure is usually too bulky to be brought to the wheel. The practical technique required to finish weld to color and tone of parent metal is given in detail together with suggested abrasives and liquid media for carrying the abrasive. WB + MS (8c)

8d. Electroplating

Method for Electrolytic Deposition of Metals and Alloys (Verfahren zur elektrolytischen Abscheidung von Metallen und Metalllegierungen). M. SCHLÖTTER. *Oberflächentechnik*, Vol. 12, Feb. 19, 1935, pages 45-46. According to this method (DRP 608268), the poisonous KCN used in many plating baths is replaced by non-poisonous thiocyanogen compounds which give deposits of equally good properties and of even finer grain. The current efficiency of these baths is almost the theoretical value and the required voltages very low. A bath for Ag plating is: 33 g. Ag thiocyanate, 200 g. Na thiocyanate, 1 l. H_2O; for Cu plating: 43 g. cuprothiocyanate, 200 g. ammonium thiocyanate, 10 g. Na sulphite, 1 l. H_2O; or 34 g. cuprochloride, 230 g. ammonium thiocyanate, 10 g. Na sulphite, 1 l. H_2O. Bath voltage 0.5, current density 100 amp./m.², efficiency 98.5% referred to cuprosalt. The deposit is dense and firmly adherent and has a better brightness than those from cyanide solutions. Brightness can be increased by addition of colloids or capillary-active substances. Ha (8d)

Accelerated Tests of Nickel and Chromium Plating on Steel. PAUL W. C. STRAUSSER, ABNER BRENNER & WILLIAM BLUM. *Journal of Research National Bureau of Standards*, Vol. 13, Oct. 1934, pages 519-526. Plated specimens similar to those used in atmospheric exposure tests were subjected to accelerated tests, especially NaCl spray and intermittent immersion in NaCl solution. The time required for the first appearance of slight rust in these tests was not consistent and showed no direct relation to the protective value of the coatings. When the extent of the rust at the end of a definite period, for example 100 hrs., was recorded, the results were approximately parallel to those of atmospheric tests. The protective value of a metallic coating against a test of this type depends principally upon its freedom from porosity. The latter can be determined in a few minutes by the ferroxyl test. WAT (8d)

Sources of Defects in Nickel Plating and Their Correction (Fehlerquellen bei der Vernickelung und ihre Behebung). ROBERT G. SNELLING. *Chemiker-Zeitung*, Vol. 58, Oct. 24, 1934, pages 860-862. Black color of a Ni deposit is due to Zn, Cu, or other impurities in the electrolyte. Dark color is caused by the solution being too cool, or not acid enough, by the current being too low, or by loose contacts. A solution temperature of 53° to 57° C is recommended. The presence of oil or grease will color the deposit yellow. Green results from insufficient single Ni salts or current conducting salts and can be corrected by adding H_3BO_3. Irregular color, spotty and streaky deposits are caused by the articles being plated or the plating solution not being clean, or by insufficient conducting salts. Rough and brittle deposits result if the solution is too concentrated either in the entire tank or at the bottom. Other causes are a solution too high in single Ni salts, too alkaline, or too high in organic compounds or colloids. Very high current produces dark, "burnt" deposits and too rapid plating produces peeling. Dull Ni results from a concentrated electrolyte, insufficient anode surface, too high a temperature, insufficient metal ions in the solution, too low current, or too low acid concentration. A solution containing much organic matter or colloid gives a shiny deposit. Uneven and irregular deposits result if the anodes and cathodes are too close together, or the bath is not agitated. Pitting is caused by too high current, too low acid, or the surface of the articles not being polished enough. Rust appearance indicates a pitted deposit. CEM (8d)

Improved Coating Applied to Wire by Electrogalvanizing. *Steel*, Vol. 95, Dec. 24, 1934, pages 22-24. Describes the Bethanizing process used at Maryland plant of the Bethlehem Steel Co. Bright steel wire, after passing through a Pb annealing bath, is cleaned electrolytically first in fused NaOH and then in acid. Zn is deposited in lead-lined electrolytic cells 55 ft. in length and wide enough to accommodate 8 wires. Zn strip anodes extending the entire length, divide the cells into compartments through each of which a single wire is drawn. Electrolyte is pure $ZnSO_4$, prepared chemically direct from roasted ore. Current density of 700-1400 amps./ft.² is used. It is claimed that the coating, which may be any thickness desired, is so ductile and adherent that it will not crack, flake, or chip off under severe distortion. MS (8d)

Chevrolet Brake Linkage Has Plated Parts for Protection. *Automotive Industries*, Vol. 71, Dec. 22, 1934, page 778. Component parts of the brake linkage at the wheel are protected against corrosion by plating with Zn, Cd, or Cr. Cd and Cr which are used on parts subjected to wear have been found useful both for protection and for reduction of friction between mating parts. BWG (8d)

8e. Metallic Coatings other than Electroplating

Machine Element Coating. CHARLES BOYDEN. *Metallizer*, Vol. 3, Dec. 31, 1934, pages 2-4, 7; *Iron Age*, Vol. 135, Jan. 10, 1935, pages 35-37. The advantages and best procedure of repairing and coating machine parts by metal spraying are discussed. Worn parts may be rebuilt quickly and usually with very little expense, often without dismantling heavy machinery. Coatings may be applied locally for corrosion resistance, wear resistance, better bearing properties, etc. About 80% of the success of the coating is said to depend on the preliminary surface preparation. If prepared by machining a rough tool mark is desirable. After spraying, the work may be finished to size by wet grinding or by machining with sharp cutting tools. VSP + BWG (8e)

Decorative Uses for Metallizing. *Metallizer*, Vol. 3, Nov. 30, 1934, pages 6-7. General procedure and a number of examples are given of sprayed metals for decorative effects. These include bronze coating of wooden letters, metallized furniture, costumes and metal impressions of masks of celebrities. BWG (8e)

Report on Recently Completed Water Tank Job. R. L. CRANE, JR. *Metallizer*, Vol. 3, Nov. 30, 1934, pages 8-9. Details are given on operating conditions, procedure and apparatus for Zn coating water-storage tanks. A sprayed Zn coating of 2 oz./ft.^{2} is claimed to outlast a hot dipped galvanized coating about 5 times. Zn applied by the metallizing process has proved very satisfactory for numerous applications. BWG (8e)

Sales Appeal of Hot-Dip Zinc Coatings. WALLACE G. IMHOFF. *Iron Age*, Vol. 134, Nov. 22, 1934, pages 10-13. Discusses various galvanizing finishes as related to consumer appeal. The various spangles are classified and discussed. The most salable and attractive type of finish is said to be the "pearly" spangle. This finish will not discolor or tarnish as quickly as others. Metal ware and sheets show spangle at its best. Large baths give smoothest coatings. One cause of rough coating is contamination of the bath with Fe. VSP (8e)

A Microscopic Analysis of Sprayed Metals. T. W. LIPPERT. *Iron Age*, Vol. 134, Aug. 30, 1934, pages 8-13. Deals primarily with microstructure of the coatings, the discussion being based on laboratory results reported by Dr. Schenk and H. Reininger of Germany. A brief history of the metal spraying process and a discussion of the various current methods are given. Practically any metal can be liquified and sprayed on any type of surface by some method. Molten metal issues from nozzle as a fine cloud, the individual particles varying in diameter from 0.0004" to 0.0006", according to the metal and position of flame. Average adherence on clean and well roughened surface is about 7 tons/in.^{2} in pull normal to surface. Microscopic examinations of Pb and Sn show that there is actual fusion of particles. Sprayed coating is considerably more porous than hot-dip or electroplated coatings. Difficulties of brushing coatings lies in excessive pressures. Heating surface before spraying is beneficial. VSP (8e)

8f. Non-Metallic Coatings

Ships' Compositions. Anti-Corrosive and Anti-Fouling Compositions. *Synthetic & Applied Finishes*, Vol. 5, Aug. 1934, pages 109-111, 125. The object of underwater paints for ships is to protect the hull against sea-water corrosion and to prevent the formation of animal and vegetable marine growths. Red lead priming is fast falling into disuse. Under the action of sea-water, some Pb chloride forms which forms a strong galvanic couple with Fe. Anti-corrosive priming coats are usually based on a water-proof medium in which are incorporated Fe oxide and suitable proportions of inhibitors such as Pb or Zn chromates and Zn oxide. Paints in which brush marks persist are inferior since deterioration usually manifests itself in the "ruts." Cargo and warships foul most heavily during long idling. Tests of Vilna definitely established that dark carriers are most favorable to vegetable growths. Earlier methods of protection by Cu and brass sheathing, electrolytic Cu coating, Cu bronze powder, amalgams, Japan lacquer are reviewed. Antifouling compositions are given. Metallic poisons having Cu, Hg or As base and organic poisons are discussed. All antifouling compositions are admitted to be more or less imperfect. Recently, rubber latex together with a vulcanizing agent has been proposed for hard, smooth coatings. EF (8f)

Reactions Important for Adherence when Firing Ground Coats containing no Adherence-promoting Oxides. A. DIETZEL & K. MEURES. *American Ceramic Society Journal*, Vol. 18, Feb. 1935, pages 35-37. In an investigation to determine adherence of ground coats to steel, test pieces were fired from 600°-900° C. for different periods. The formation of "hammer scale" between steel and enamel layer showed strong oxidation in spite of enamel coat. Three stages of firing are described; in stage A, the initially formed hammer scale dissolves in enamel, oxide present is reduced by Fe to FeO, atmospheric oxygen by diffusion reoxidizes Fe'' to Fe''' which leads to saturation of enamel with Fe oxide and precipitation of Hastingsite, a constituent containing both Fe'' and Fe''', finally magnetic oxide, Fe_3O_4 forms. In stage B, the oxidation of FeO and the formation of magnetic oxide is completed. In stage C, firing is completed and "Cu heads" appear which are due to red hematite (Fe_2O_3) crystals formed from Fe_3O_4. The practical significance of the work is that enamels which do not contain Co and Ni oxides can adhere properly if they are correctly fired. It is claimed that the cause of this adherence has been found. WB (8f)

Drying and Baking With Inductive Electric Heat. *Industrial Heating*, Vol. 2, Feb. 1935, pages 93-95. Describes a few examples to show that induction heating can advantageously be applied for drying and baking painted or enameled metals whereby the metal itself is heated inductively without external application of heat. Ha (8f)

1 **Marine Uses for Aluminum Paint.** *Marine Engineering & Shipping Age*, Vol. 40, Jan. 1935, pages 8-9. Description of use of Al paint on both metal and wood for protection and attractive appearance. The pigment is composed of Al powder or paste consisting of tiny flat flakes of pure Al. When mixed with a suitable vehicle and applied to a surface, many of the flakes crowd to the outer surface of the coating where they "leaf out" to form a practically continuous film. Kz (8f)

— **Film Coverings as Applied to Finishes. Heat-Sealing Moisture-proof Cellulose Film.** *Synthetic & Applied Finishes*, Vol. 5, Nov. 1934, pages 190-192. Protection is often necessary in the form of a paper or other wrapping to safeguard metal finishes or organic coatings against dirt or soiling or the possibility of corrosion from external influences such as crude cardboard box packages under moist conditions. The wrapping of polished or silver and gold electro-plated articles, small tools, instruments and similar objects of more expensive nature is included in this field. Water vapor penetration tests on moisture-proof cellulose films are reported. EF (8f)

2 **Are Synthetic Resins of the Phenolic Type Suited for Coatings on Food Cans? (Sind Kunstharze vom Typus der Phenole zur Herstellung von Konservendosenlacke geeignet?)** J. HARLASS. *Farben Zeitung*, Vol. 39, June 23, 1934, page 653. Discusses the chemical reactions between preserved fruits and lacquer coatings in food cans and the corrosion effects resulting from cracking of lacquer coatings. Methods for physical and chemical testing of food-can lacquer coatings are described. The suitability of phenolic resins is discussed critically and test results on a "superbeckacite 1001" tung oil (1 : 2) varnish showed that it passed all requirements and discredited the statement that this type of coating is responsible for the spoiling of preserves. EF (8f)

— **Zinc Powder—An Excellent Pigment in Industrial Paint.** *Synthetic & Applied Finishes*, Vol. 5, Aug. 1934, pages 107-108; *Farbenzeitung*, Vol. 39, Oct. 27, 1934, page 1098. Atmospheric exposure tests of panels of Bessemer steel exposed at a 45° angle demonstrated the superior rust-inhibitive qualities of Zn-dust paints which result from electrochemical action. Bright steel samples were embedded in graphite, Pb chromate, Zn dust, Al powder, red lead, blue lead, Fe oxide and magnetic Fe oxide respectively and maintained in an ozonized, intermittently-heated atmosphere. All became dull except the samples in Zn dust and Pb chromate. The greater adhesive power of Zn dust-Zn oxide paints over other commonly used metal-priming paints is demonstrated. Zn-dust paints are recommended as good primers for other finishing coats, and are used for Fe and steel surfaces in plant and bridge maintenance. They are particularly suited for underwater service. EF (8f)

3 **The Eloxal Process (Das Eloxalverfahren).** H. SCHMITT, A. JENNY & G. ELSSNER. *Zeitschrift Verein deutscher Ingenieure*, Vol. 78, Dec. 29, 1934, pages 1499-1506. The electrolytic oxidation of Al and its alloys and the properties and application of the treated metal are discussed exhaustively. The process can be used to obtain a variety of results, e.g. wear resistance, hardness, surface electric insulation, or ornamental appearance; almost any color can be produced on aluminum by using the oxide film as a basis for holding the dye. Ha (8f)

— **Problem of Raw Materials. New Domestic Paint Coatings and Painting of Steel Structures (Rohstofffragen-Werkstofffragen. Neue einheimische Anstrichstoffe und der Anstrich von Stahlbauwerken).** B. SCHEIFELE. *Farben Zeitung*, Vol. 39, Nov. 10, 1934, pages 1144-1146; Nov. 17, 1934, pages 1167-1169. Paper before the Fachausschuss für Anstrichtechnik, Frankfort, Oct. 19, 1934, summarizes the status of rust-inhibiting paint coating technique emphasizing recent German developments involving domestic raw materials. Prevention of corrosion in cases of special chemical attacks is considered and the increased service life of structural steel work by improved maintenance methods is discussed. 13 references. EF (8f)

4 **The Use of Finely Milled Enamel Slips.** F. R. PORTER & H. H. HOLSCHER. *American Ceramic Society Journal*, Vol. 18, Feb. 1935, pages 39-42. Durability of enamel coatings depends on thickness. Thin coats resist abuse better than thicker ones. Tests of 0.012" coatings show impact and twist values about 2 times those for 0.024" coatings. The thin coat involves problems of opacity, color standards and shop-working properties. The effect of fineness of grind on these problems was investigated. The usual 4-9% on 200 mesh has been replaced in the particular case with 12-0.2% on 325 mesh in production in continuous furnace. Advantages claimed are higher opacity, less wear on spray guns, smoother finishes, better suspension, lower firing cost and temperatures. WB (8f)

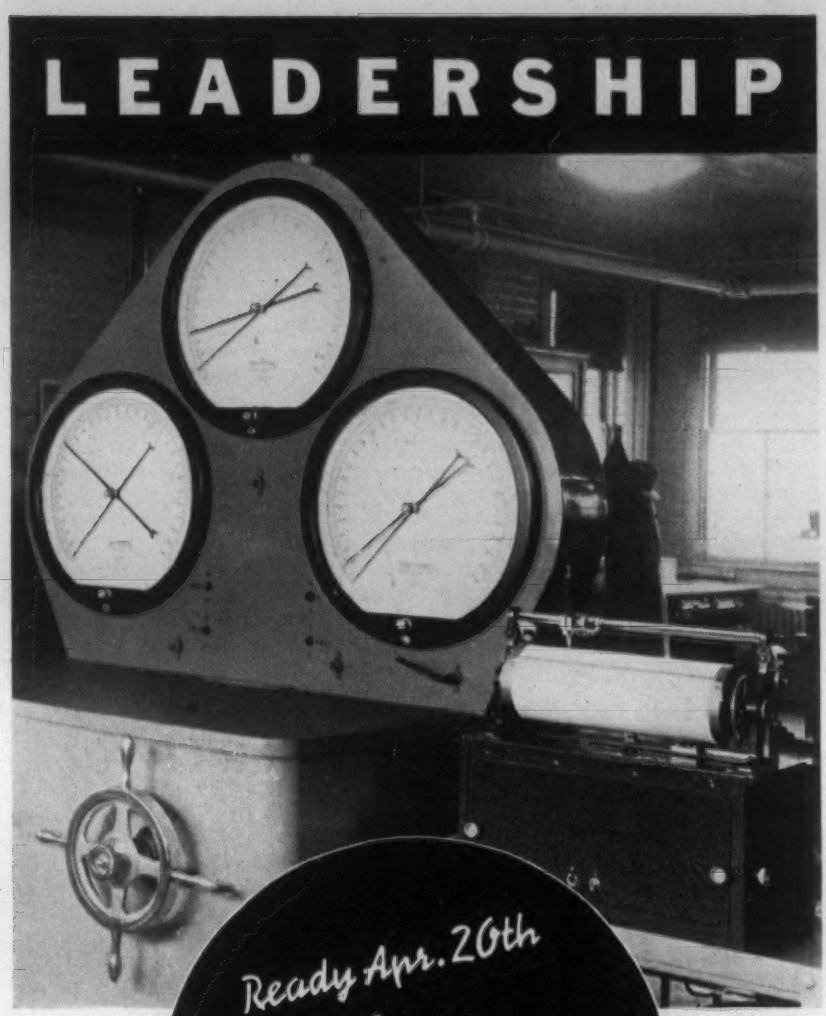
— **Fillers and Binders for Priming Materials (Füllstoffe und Bindemittel für Spachtelmassen).** H. HEBBERLING. *Oberflächentechnik*, Vol. 12, Jan. 22, 1935, pages 15-16. Technique of priming surfaces to be highly polished for taking one or more coats of lacquer or varnish is discussed and the preparation of the primers described. These consist usually of chalk, fluorspar, lithopone, or white lead. Coatings of artificial copal or cellulose lacquers are applied. Ha (8f)

5 **Enamelling Iron, Its Behavior in Enamelling.** KARL KAUTZ. *Sheet Metal Industries*, Vol. 8, Oct. 1934, pages 587-588. See *Metals & Alloys*, Vol. 5, Nov. 1934, page MA 527. AWM (8f)

— **Brown-Dyeing of Copper and Copper Alloys (Braunfärbeverfahren für Kupfer und Kupferlegierungen).** H. KRAUSE. *Oberflächentechnik*, Vol. 11, Dec. 4, 1934, pages 263-265. See *Metals & Alloys*, Vol. 5, July 1934, page MA 343. Ha (8f)

6 **Pipe Protection by Applied Bitumen.** *Industrial Chemist*, Vol. 10, Nov. 1934, pages 417-422. Methods employed by the British Tube Works, Coatbridge, England, for applying bituminous linings or coverings to pipes. RAW (8f)

7 **How Attractive Finish Helps Metal Products Sales. 30—Novelty Coatings and Synthetics.** HERBERT R. SIMONDS. *Iron Age*, Vol. 135, Jan. 17, 1935, pages 22-26, 78 Describes many of the present day novelty finishes and gives the composition and properties of synthetic enamels in considerable detail. VSP (8f)



1934—Year of great activity among steel companies in establishing research laboratories.

It is a noteworthy fact that Southwark furnished testing machines for every new laboratory represented in this group.

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❖ ❖ ❖

Illustrated above: Southwark-Templin Stress-Strain Recorder in use with a Southwark Hydraulic Testing Machine in the research laboratory of a prominent steel manufacturer specializing in stainless steels.

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9. TESTING

9a. Inspection & Defects, including X-Ray Inspection

C. S. BARRETT, SECTION EDITOR

Fracture Tests and Ingot Defects. J. H. Hruska. *Blast Furnace & Steel Plant*, Vol. 22, Dec. 1934, pages 705, 707; *Heat Treating & Forging*, Vol. 20, Dec. 1934, pages 606-607. Brief discussion of crystalline, fibrous, woody, and slaty fractures in hot-worked steels. Fibrous structures are sometimes desirable, and in other instances, harmful. Specimens cut transversely to the fiber show low impact and ductility values. Fibrous grades have better endurance properties than crystalline types when load is applied transversely to the fiber. Fiber seems to develop under the combined effects of silicate inclusions and elongation or disintegration of dendrites. Woody fractures occur mainly in steels containing Ni or Cr or both, especially if produced in large basic furnaces. Defect is associated with presence of 44-52% CaO + MgO in the inclusions in the steel. Prolonged soaking of ingots or blooms prior to rolling or forging will partly remove the defect. Slaty steel is found rarely. Elongated inclusions, principally silicates, occur in the "slate." The defect can not be corrected by any thermal or mechanical treatment that has as yet been tried. MS (9a)

Inspection of Die-Castings. E. Stevan. *Metal Industry*, London, Vol. 45, Sept. 7, 1934, page 222. A broad, general discussion in which it is pointed out that, particularly in establishments where die-castings are made according to the customers' specifications, careful inspection is necessary in all parts of the plant. This should cover all phases of the work from the design and drawings to the finished product. Inspection is a sound financial investment that pays for itself in exercising control through all stages of production. Some phases may be accomplished by unskilled labor under supervision but, in general, skilled labor is necessary. HBG (9a)

Spark Test for Steel. *Horological Journal*, Vol. 77, Jan. 1935, pages 156-157. A simple description of spark types for various C contents and discussion of color and spark identification of W tool steel and W magnet steel. WB (9a)

New Apparatus for Testing of Seams of Welded Pipes (Ueber ein neues Prüfgerät für Rohrschweissnähte). J. F. Kesper. *Autogen Schweisser*, Vol. 7, Oct. 1934, pages 140-141. See "Novel Testing Apparatus for Tube Welds," *Metals & Alloys*, Vol. 6, Feb. 1935, page MA 64. Kz (9a)

Directions for the Testing of Welded Joints with X-Rays and Gamma Rays (Richtlinien für die Prüfung von Schweissverbindungen mit Rönten- und Gamma strahlen). Berthold. *Autogene Metallbearbeitung*, Vol. 27, Dec. 15, 1934, pages 392-394. Reproduction of the regulations submitted to the German Association for Technical X-ray Research. Ha (9a)

9b. Physical & Mechanical Testing

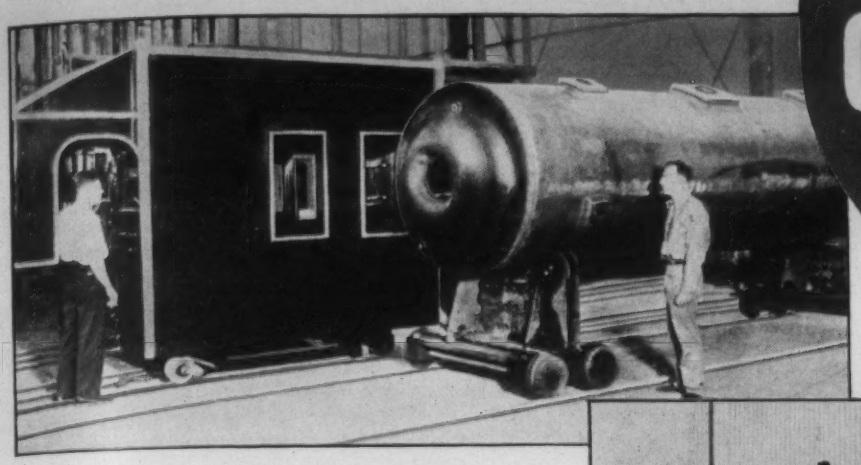
W. A. TUCKER, SECTION EDITOR

Connection between Cohesion and Plasticity (Concerning the Strength of Stretched and Compressed Specimens) (Zusammenhänge zwischen Kohäsion und Plastizität (Zum Festigkeitseffekt gereckter und gedrückter Proben)). W. Kuntze. *Zeitschrift für Metallkunde*, Vol. 26, Sept. 1934, pages 197-198. A rebuttal to the paper of N. N. Dawidenkow and E. M. Schewandin (*Zeitschrift für Metallkunde*, Vol. 26, Sept. 1934, pages 193-196) in which were questioned the views of the author, concerning the applicability of strength test data on notch-bar specimens of pre-stretched and pre-compressed metal to a determination of the ideal resistance to rupture of a metal, and concerning the validity of the concept of oriented micro-fissures for explaining the results of these tests. The author adheres, for the most part, to his original opinions. FNR (9b)

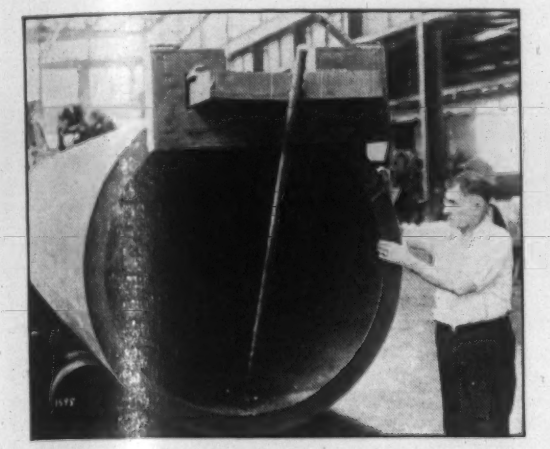
Comparison of Bending Test and Resiliency Test (Raffronto fra le Prove di Piegatura e di Resilienza). S. Menghi. *Industria Meccanica*, Vol. 17, Jan. 1935, pages 1-8. Experiments with these 2 test methods showed that bending tests alone do not reveal the quality of a steel any more than the tensile test; defects scattered in the material cannot be discovered by it. The resiliency test proves the structural uniformity of a specimen better and faster. Test methods are described. 16 references. Ha (9b)

Elongation in Long Gage Lengths (Dehnung bei grossen Messlängen). K. L. Meissner & W. Stenzel. *Zeitschrift für Metallkunde*, Vol. 26, Nov. 1934, pages 254-255. The elongation of duralumin DM31 specimens of cross section 1.25 x 20 mm. was measured in gage lengths of from 30 to 2000 mm. It was demonstrated that the total elongation arises from two sources: (1) a uniform elongation throughout the length of the specimen, (2) a localized elongation occurring in the region of necking. The uniform elongation amounted to 53% of the total in specimens having a gage length of 10 times the effective diameter of the cross section. The localized elongation becomes an insignificant factor in the elongation of specimens of gage length 30 and more times the effective diameter. Specimens having a gage length in excess of 100 times the effective diameter tend to develop more than one zone of localized elongation thus increasing the total elongation abnormally. Plots are given of: (1) total elongation versus the ratio of gage length to cross-sectional diameter, and (2) local mean elongation versus distance from the end of the specimen. FNR (9b)

HEDGES-WALSH-WEIDNER *Installs Second* GENERAL ELECTRIC X-RAY UNIT

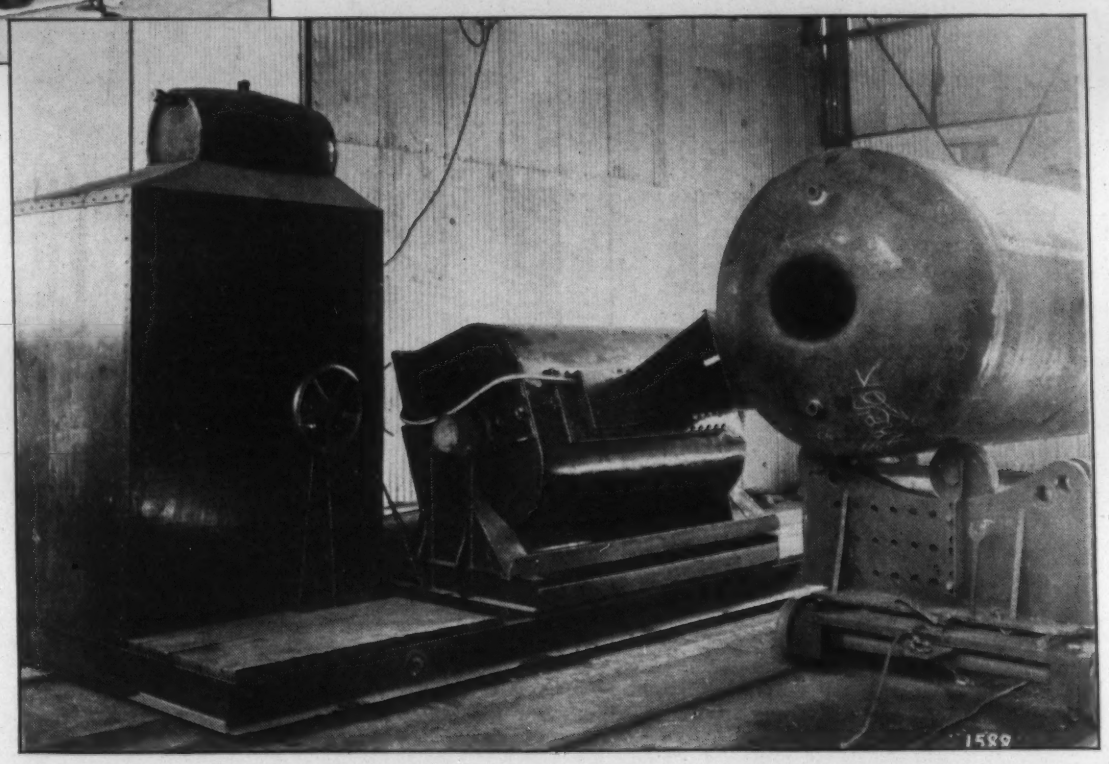


Original KX-3 X-Ray Unit in Hedges-Walsh-Weidner plant



A typical welded tube, ready for inspection of longitudinal seams

Hedges-Walsh-Weidner's latest Oil-Immersed KXC-1 X-Ray Unit



WHEN a boiler manufacturer invests in a G-E x-ray unit for the examination of fusion welds in pressure vessels, one *might* assume that he may be doing so simply to comply with the A. S. M. E. Class I Boiler Code. The purchase of additional G-E x-ray equipment, however, *must* mean that the performance of the initial x-ray unit was not only satisfactory, but profitable enough to warrant further investment in similar apparatus.

Early in 1931 the Hedges-Walsh-Weidner Company installed a General Electric KX-3 industrial x-ray unit in their Chattanooga, Tenn., plant. Writing of their experience with this equipment in "Combustion" for September, 1931, they said in part:

> "The responsibility of guaranteeing the soundness of the entire welded seams of a large number of pressure vessels is a burden which is too heavy to be placed upon any visual inspection during fabrication.* * *
>
> "X-ray examination of weld seams is not new. But improvements in x-ray equipment within the past few years have furnished the industry with a thoroughly reliable and practical inspection tool for just such work. The x-ray constitutes a homogenity test. As a non-destructive test applied to weld seams, it completes from the point where the physical test of sample coupons leaves off. It furnishes positive assurance as to whether the welding in the seam of the completed vessel is as good as that in the test samples. It will unfailingly detect any appreciable porocities or cracks which may possibly occur in the main seam, yet be absent from the test samples. Realizing the immense value of x-ray examination in connection with physical testing of sample specimens, the A.S.M.E. Boiler Code Committee has specified its use in their recent code covering welded construction when applied to pressure and power boilers.***
>
> "An x-ray installation, such as this, enables the boiler manufacturer to verify the results of his welding process and thus places him in a position to assure the satisfactory performance of the welded drums manufactured in his plant."

More than three years' experience has evidently justified Hedges-Walsh-Weidner's original evaluation of the x-ray, and of General Electric equipment for its generation, for they have recently added a G-E Oil-Immersed KXC-1 unit to their equipment. This shock-proof apparatus is more powerful than their first model and, with the x-ray tube and complete high-voltage system sealed in oil within a single "head," it is much more compact and flexible—and 100% elecrically safe.

General Electric offers a complete line of industrial x-ray equipment—from small units for fluoroscopy and light radiography up to powerful 400,000-volt apparatus. There are designs for portable, mobile and stationary work, for specialized and routine applications. Tell us your problem—perhaps we have already solved a similar one. At any rate, our advice is yours for the asking, without obligation of course.

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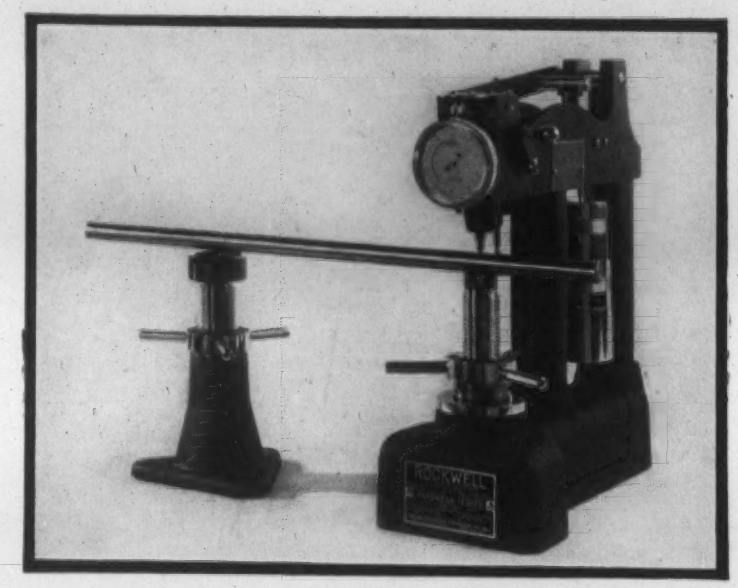

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9c. Fatigue Testing

H. F. MOORE, SECTION EDITOR

The abstracts appearing under this heading are prepared in cöoperation with the A.S.T.M. Research Committee on Fatigue of Metals.

The Relation of Fatigue to Modern Engine Design. R. A. MacGregor, W. S. Burn & F. Bacon. *North-east Institution of Engineers and Shipbuilders*, British, Advance copy, Jan. 1935, pages 1-66. Part I is a review by a manufacturer of steel propeller shafting of his experience with failures in service. An excellent selection of photographs of failures of shafts and axles by fatigue and by corrosion-fatigue are given. In answering complaints of customers it was possible to show that "stress raisers" due to design or to installation practice always led to the same type of fatigue failure. It has been sometimes wrongly assumed that the determination of stress-concentration alone was sufficient to serve as a basis for design for any metal, but tests have clearly shown that different metals, or even different steels, show wide differences in resistance to stress concentration—they have widely different "notch sensitivities." It is necessary not only to know the effect of the shape of the "notch," but also the notch sensitivity of the metal of which the shaft is made. In this connection the author points out that it is unfortunate that no more attention has been paid to the spread of a crack under cyclic stress. A spreading crack constitutes an exceptionally effective stress raiser, and since most machine parts have to withstand occasional stresses above their primitive endurance limit, the ability to resist crack spread, as well as crack formation, is important. Types of corrosion-fatigue encountered indicate not only repeated torsion, but also the presence of repeated or reversed tensile stresses. Sometimes after a shear crack (transverse or longitudinal) is started the diagonal tensile stresses, which always accompany shearing stresses, come into play to cause the crack to change its direction and follow a helicoidal path. Failures of mild steel and alloy steel in motor truck axles, due to oil holes, keyways and hair cracks during smithing are cited, with illustrations. Part II. The part played by design in overcoming fatigue failure is indicated, and good and bad design practice is pointed out. The factors limiting or influencing design are summed up under the heads of effect of "grain" (macroscopic fiber), effect of microscopic grain size, effect of alloying elements, of hardening processes, fatigue test results (noting type of test) effect of scale, effect of size on notch sensitivity, surface quality in relation to the size of the part, Izod (or Charpy) notched bar test results, overstressing without crack formation, crack spread and core strength. Part III. This part is a straightforward critique of the test methods now used to obtain fatigue data and conceptions involved in application of Hookes law to metals in service under stress reversal. Two tests are described in which specimens of a certain (unspecified) high alloy, resistant steel are fatigue tested. Both the plain and notched specimens could have been run indefinitely according to the author at a high stress while heat was generated to such an extent that the specimens were too hot to touch with the hand. The energy expended in elastic hysteresis of the metal instead of in starting a crack is assigned as the reason for non-failure. In same steel the combination of high notch toughness and high internal damping resists cracking due to stress concentration. The significance of high internal damping in resisting fatigue failure is that the distortion increases more rapidly than the stress with the result that the highly strained material at the bottom of the notch is stress relieved. In other steels in the heat treated alloy group (which the author again does not specify) with a stricter conformity to Hookes law and high elastic ratio, stress relief at the bottom of the notch does not occur because such steels are extremely notch-sensitive. (It may here be noted that the paper by McAdam, abstracted elsewhere in this section, indicates that ability to gain strength as the result of strain hardening seems to be fully as important in lessening notch sensitivity as is hysteresis.) Sharp grooves in such steels may decrease fatigue limit to 40% of plain polished value. Straight C steels in normalized and annealed states are intermediate in behavior between the 2 alloy groups cited. The author criticises use of small .400" diameter specimens for fatigue tests in which the results are expected to be interpreted in terms of service design of large parts. Stress concentration appears as an entirely different situation when produced by notching a .400" specimen and in rough turning a 20" crank pin. To obtain the same relative effect in the small specimen the notch will be of grain-size dimension. He favors notched specimens not less than 1" in diameter. Another criticism is that the main value sought in fatigue tests is the limiting stress below which fracture will not occur, no matter how many cycles of stress are applied: no attention is paid to the rate of spread of a crack, once it is formed. The author has been successful in designing a method for measuring the rate at which cracks spread and claims to have obtained very consistent values from specimen to specimen of the same bar. An excellent selective bibliography is appended, which supplements the references to be found in "Gough," in "Moore and Kommers" and in the 1930 report of the Am. Soc. for Test. Materials Committee on Fatigue of Metals. WB + HFM (9c)

Relation of Impact and Tension Tests of Steel. H. C. Mann. *Metal Progress*, Vol. 27, Mar. 1935, pages 36-41. Author calls attention to conclusion to be reached from Impact Testing Symposium of American Society for Testing Materials, 1926 that results of transverse impact tests are not sufficiently discriminating except for large differences in materials, results are not in terms applicable to design and results of different machines are not comparable. Tensile impact tests of notched specimens when considered with static tests have been useful in determining the acceptability of certain classes of ordnance forgings. It is shown that material has capacity for absorbing a limiting amount of energy per unit of volume and that there is a definite limiting rate of energy absorption. A specimen 2.5" between shoulders broke with 1300 ft. lb. and 5" specimen of same diameter absorbed 2100 ft. lb. without breaking. Speed of application of impact has greater effect upon some materials than others. 18-8 stainless steel is very markedly affected by changes in velocity of impact between 0 and 8 ft./sec. whereas armor plate is unaffected by changes in velocity of impact. Energy absorbed during testing does 2 things, deforms the specimen and heats it. It is found that the ordinary load-elongation curve taken in a tensile test encloses an area representing the work of deformation and that if the curve is plotted taking the reduced diameter into consideration in plotting of stress the area under this curve is equivalent to total energy and area between these curves when superimposed gives the energy used in heating the specimen. WLC (9b)

Machine with a Photographic Attachment Designed for Mechanical Testing of Small Test Samples of Metals (Micromachine à Enregistrement Photographique pour l' Essai Mécanique des Métaux). Pierre Chevenard. *Comptes Rendus*, Vol. 200, Jan. 14, 1935, pages 212-215. A description is given of a machine to be used for testing metals in tension, shearing and bending with a stress-strain recorder built on optical principles. Test specimens are 1 to 1.5 mm. diameters which makes it possible to study small areas where burning has taken place, decarburization or any other localized condition. FHC (9b)

Testing of Sheets for Deep Drawing. H. Diergarten. *Metal Progress*, Vol. 27, Mar. 1935, pages 60, 62. Discusses the value of bend test for quality of sheet for deep drawing. WLC (9b)

Modulus of Elasticity. Modern Conceptions and Recent Work (Le Module d'Elasticité. Conceptions Modernes et Travaux Récents). Léon Guillet, Jr. *La Technique Moderne*, Vol. 27, Jan. 15, 1935, pages 41-45. Describes actual knowledge on the matter. (1) Modulus of elasticity in tension : What must be considered as Young's modulus is described, it is pointed out that in the case of cast Fe in which permanent deformations are noted under very low stresses the modulus varies from one point to the other in the stress-elongation curve. Much difficulty is met with in measuring Young's modulus. Indirect method of the Le Rolland and Sorin pendulum is good because it is very close to theoretical optimum conditions of precise modulus measurement. (2) Elastic modulus in compression: It is said that for short samples this modulus is the same as in tension. (3) Elastic modulus in torsion (Coulomb's Modulus) is briefly discussed. (4) Effect of various factors on elastic modulus, influences of chemical composition, working and heat treatment are studied. FR (9b)

Fatigue in Structural Steel. B. P. Haigh. *Engineering*, Vol. 138, Dec. 28, 1934, pages 698-701. Gives a description of two series of tests carried out at the Royal Naval College at Greenwich to investigate fatigue cracking in (1) a mild steel with a tensile strength of about 65,000 lb./in.² and a "Chromador" steel containing about 0.93% Cr and with a tensile strength of about 90,000 lb./in.² Fatigue tests were carried out in a Haigh fatigue testing machine, which produces cycles of axial stress by means of a pair of two-phase electromagnets. The stress was applied to the specimens in the direction of rolling, and the metal was in the "as rolled" condition, except that the critical section was turned and polished. Tables are given for chemical composition, for static strength and for the results of the fatigue tests. Over a considerable variety of ranges of stress and both for standard specimens and for specimens with radial holes in them, the ratio of fatigue strength of the "Chromador" steel to that of the mild steel was about 1.50. It is pointed out that since the main stresses on structures are static, and since for non-reversed cycles of stress the fatigue strength of both steels was usually above the static yield point strength, hence the yield point is the most commonly useful criterion of strength for both these structural steels. VSP + HFM (9c)

9d. Magnetic Testing

L. REID, SECTION EDITOR

Magnetic Properties of Iron and Steel, Report of Committee A-6. *Proceedings American Society for Testing Materials*, Vol. 34, Pt. I, 1934, pages 186-187. Progress report. Revised definitions of electrical terms will be found in the 1934 Supplement to Book of A. S. T. M. Standards, page 69. VVK (9d)

Magnetic Properties of Thin Layers of Ni (Propriétés Magnétiques des Lames Minces de Nickel). ANDRÉ ARON. *Comptes Rendus*, Vol. 200, Jan. 14, 1935, pages 228-230. Describes results of determinations of magnetic properties on Ni deposits so thin that they transmit light. FHC (9d)

Drift of Magnetic Permeability at Low Inductions After Demagnetization. RAYMOND L. SANFORD. *Bureau of Standards Journal of Research*, Vol. 13, Sept. 1934, pages 371-376. The magnetic permeability of ferromagnetic materials at low values of induction depends upon the time which elapses between demagnetization and testing. The change may be of the order of 10 or 12%. In order to obtain consistent and reproducible results in testing at low inductions, a period of from 18 to 24 hrs. should elapse after demagnetization before the test is made. When this precaution is taken, values obtained on the same specimen by the two methods permitted by the specifications of the American Society for Testing Materials should be in agreement within the allowable experimental error. WAT (9d)

9e. Spectrography

New Technique in the Crystalline Spectography of Gamma Rays (Nouvelle Technique dans la Spectrographie Cristalline des Rayons γ). HORIA HULUBEI. *Comptes Rendus*, Vol. 199, Oct. 29, 1934, pages 857-859. A description is given of a method of focusing γ-rays from radon for spectographic analysis of crystals. FHC (9e)

Concerning a New Property in the Analysis of Crystal Structure (Über eine neue Eigenschaft der Strukturanalyse). N. SELJAKOW. *Zeitschrift für Physik*, Vol. 92, Nov. 30, 1934, pages 543-546. X-ray spectographs made according to the rotating crystal method are influenced to a greater extent by the use of large reflection angles than by smaller angles. FHC (9e)

Concerning the Application of Valouch's Method for Measuring Crystal Lattice Constants by the Precision Method of Kunz & Köppel (Sur l'Application de la Méthode de Valouch, pour Mesurer les Constantes des Réseaux Cristallins, a la Méthode de Précision de Kunzl et Köppel). F. BOUCHAL & V. DOLEJSEK. *Comptes Rendus*, Vol. 199, Nov. 12, 1934, pages 1054-1056. Precision measurement of a crystal lattice is difficult due to inability to adjust accurately the surface of the crystal on the spectographic axis. The Kunzl-Köppel method applied the exact Bragg equation and elaborated a precise method by measuring the difference K of 2 angles of reflection (instead of measuring directly the angle of reflection). Valouch developed a method for the crystal lattice based on measuring the difference of the angle of reflection of the same order for 2 different lines. Authors apply 2 Bragg equations of same order but for different wave lengths,

$$n\,\lambda\nu = 2d \sin \Theta n\nu \qquad n\,\lambda\mu = 2d \sin \Theta n\mu$$

Dividing the sum of these two equations by their difference, the following formula results for each trial value of the lattice constant:

$$d_n = \frac{n}{4}\left[\left(\frac{\lambda\nu - \lambda\mu}{\sin K/2}\right)^2 + \left(\frac{\lambda\nu + \lambda\mu}{\cos K/2}\right)^2\right]^{1/2}$$

$$\text{or} \quad K = \Theta\nu - \Theta\mu \quad \text{and} \quad \lambda\nu > \lambda\mu$$

The trial value d_n agrees with the value $d\mu$ calculated from the angles of reflection. Studies were based on Cu-Fe; Fe-Cr and Cu-Cr. FHC (9e)

Arc-Spectrum Determinable Elements in Lead Minerals (Bogenspectralanalytisch nachweisbare Elemente in Bleimineralien). S. PIÑA DE RUBIES & J. DOETSCH. *Zeitschrift für anorganische und allgemeine Chemie*, Vol. 222, Feb. 13, 1935, pages 107-112. The preparation of samples and the methods of examination are given for various Pb minerals. The elements found in the minerals are detailed and percentages given in most of the cases. WB (9e)

Some Spectro-analytical Experiences with High Frequency Excitation (Über einige spektralanalytische Erfahrungen mit der Hochfrequenzanregung). K. RUTHARDT. *Metallwirtschaft*, Vol. 13, Dec. 7, 1934, pages 869-871. High frequency excitation in spectrographic analysis is especially useful for easily volatile and burning materials, such as in the examination of animal and vegetable matter and filtered residues for metals, of metal foil, salts, some minerals, and bones. It is not suitable for solid metals and solutions. It is highly sensitive, as .1 to 1 gamma/gram can be detected in .1 gram samples. It is not practical to dissolve such small samples and no preliminary preparation is necessary. The equipment and circuit used is similar to that of Gerlach and Schweitzer, with some differences which are described. A very thin glass plate is cemented to a metal plate. A filter paper moistened with $NaNO_3$ is placed on the glass plate and the sample on the filter paper. A 1 mm. diam. Au or Pt wire is used for the other electrode. A strong spark is necessary. Methods for controlling and changing the energy are described. High frequency does not disturb the surface of compact metals as much as other methods of excitation. In dry samples the spark remains in one spot and heats the sample up to redness. When moist samples are used a majority of arc spectrum lines are obtained, with dry samples the majority are spark lines, and this must be taken into consideration in interpreting results. Quantitative results are also possible. There is not much interference from bands. CEM (9e)

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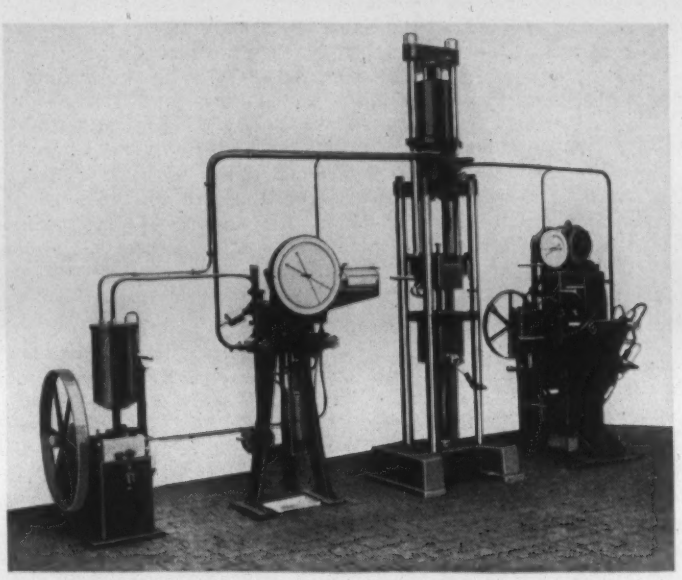

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10. METALLOGRAPHY

J. S. MARSH, SECTION EDITOR

Manner in which Carbon is Bound in Hardened and Tempered Steels (Ueber die Bindungsform des Kohlenstoffs in gehärteten und angelassenen Stählen). F. Wever. & G. Naeser. *Mitteilungen aus dem Kaiser-Wilhelm-Institut für Eisenforschung, Düsseldorf,* Vol. 16, No. 18, 1934, pages 201-206. Authors tried to determine, by analyzing the residues of tempered steels obtained by electrolysis in iron chloride solutions, the manner in which C is bound in steel at different temperatures. The residues are separated magnetically in 2 parts, one essentially highly dispersed C in water, the other a gray-black powder which, when dry, ignites in air. The C content of the unseparated residue decreases with increasing tempering temperatures from very high values in untempered steels to that of Fe_3C at 700° C., while the C content of the purified residue is mostly FeC up to about 300°, and Fe_2C between 300° and 600°-700° C.; the composition of cementite is reached above 700°. Residue of steels transformed directly from austenite have lower C contents than tempered steels and correspond to Fe_2C for transformation temperatures of 400°-500°. The existence of the carbides FeC and Fe_2C in tempered steels is considered as certain. 23 references. Ha (10)

Iron-chromium, Iron-chromium-nickel and Related Alloys, Report of A.S.T.M. Committee A-10. *Proceedings American Society for Testing Materials,* Vol. 34, Pt. I, 1934, pages 190-192. Progress report. **The Polishing and Etching of Iron-chromium and Iron-chromium-nickel Alloys.** J. R. Vilella. *Appendix,* pages 193-204. The alloys are divided into three groups: I—alloys containing more than 0.50% C., II—alpha or ferritic alloys containing less than 0.50% C., and III—low-carbon austenitic alloys. Detailed directions are given for polishing and etching. VVK (10)

Ternary System: Copper-silver-cadmium (Il sistemo ternario: rame-argento-cadmio). L. Losana & C. Goria. *Industria chimica,* Vol. 9, Dec. 1934, pages 1603-1615. A complete study of the composition and cooling curves of the system Cu-Ag-Cd, combining the results of studies of the binary systems involved, has been made. The equilibrium diagram is very complex. Several useful alloys are indicated: (a) Cd 81, Ag 12, Cu 7%, m.p. 490°-505°C.; (b) Cd 57, Ag 6.5, Cu 36.5%, m.p. 535°-550°C.; and (c) Cd 39, Ag 40.5, and Cu 20.5%, m.p. 670°C. These alloys resist oxidation, but are fragile, especially (c). They are useful in making fusible safety plugs, etc. AWC (10)

Nodular Troostite, Its Structure. Francis F. Lucas. *Metal Progress,* Vol. 27, Feb. 1935, pages 24-28. Structures illustrated are those in a ½" hot-rolled round as received. Micrographs show that with increasing magnification and high resolving power portions showing structureless at lower magnification become first cloudy and then show more less-well-defined laminations of pearlite. Tempering is without effect upon size of troostite nodules but results in coalescence of carbide. WLC (10)

An Approximate Value of the Heat of Formation of the Iron Phosphide, Fe_2P (Ein Näherungswert für die Bildungswärme eines Eisenphosphides [Fe_2P]). W. A. Roth, A. Meichsner & H. Richter. *Archiv für das Eisenhüttenwesen.* Vol. 8, Dec. 1934, pages 239-241. The heat of formation of crystallized $FePO_4$ from Fe_2O_3 and P_2O_5 was found to be + 21.6 Kcal by solution in HCl. The heat of formation from the elements was + 303.9Kcal using red P. The most probable value, accurate to about 10%, for the heat of formation of Fe_2P from $2Fe_\alpha + P_{red}$ is 41 K cal. The values are referred to 20°C. at constant pressure. Attempts to completely combine Fe and P in an evacuated bomb through electric heating were unsuccessful. The heats of formation of the other comounds of Fe and P were calculated to be

$$Fe_\alpha + P_{red} = FeP + 28.5 \text{ K cal}$$
$$Fe_\alpha + 2P_{red} = FeP_2 + 37.5 \text{ K cal}$$

The values are all positive and must be considered in calculating the heat reactions in the basic Bessemer process. SE (10)

Deformation and Orientation Through Surface Working (Machining) of Iron (Verformung und Regelung durch Oberflächenbearbeitung (Spanabhub) bei Eisen). M. Renniger. *Metallwirtschaft,* Vol. 13, Dec. 14, 1934, pages 889-892. The effect of machining on the surface of ordinary annealed forging steel was studied by means of X-ray diffraction patterns. Machining caused the disappearance of diffraction rings of individual crystallites and general broadening of the ring, both of which indicate formation of smaller grain size or internal strains. It also caused irregular intensity distribution along the ring, which indicates preferred orientation due to deformation. The size of these effects varied greatly with the machining conditions. Varying the speed of machining, other conditions remaining constant, made no difference in the deformation on the surface of the remaining steel, but slower speeds produced deformation to a greater depth than faster speeds. The preferred orientation was determined by taking X-ray photographs of a sample at various angles. CEM (10)

Gold-copper Alloys, Especially at Elevated Temperatures (Gold-Kupferlegierungen, insbesopdere bei hohen Temperaturen). L. Vegard & Arne Kloster. *Zeitschrift für Kristallographie, Kristallgeometrie, Kristallphysik, Kristallchemie,* Vol. 89, Dec. 1934, pages 560-574. Gives full details on the X-ray equipment specially constructed for taking X-ray pictures of Au-Cu alloys at elevated temperatures. A random atom distribution was found at 475°C. proving the non-existence of the previously reported compounds CuAu and $CuAu_3$. Although the Cu-Au system shows a continuous series of solid solutions at 475°C. the law of addition is not strictly fulfilled. At room temperature, the Cu-Au system exhibits no lines of the compounds mentioned. Solid solution with random distribution prevails. Around 50 at. %, the interference lines were particularly blurred, which phenomenon is designated as "micro-destruction." As far as the lattice dimensions at room temperature could be determined, deviations from the addition law were noted, as was true at elevated temperatures with respect to direction and magnitude. The widths of the lines indicates that the "micro-destruction" becomes less pronounced with rising temperatures. Previous work on the Cu-Au system is reviewed. 15 references. EF (10)

Secondary Crystallization of Steel in Connection with the Formation of Widmanstätten Structure. V. N. Svechnikov & M. I. Schepak. *Domez,* No. 9, 1934, pages 29-49. Paper starts with a very comprehensive critical review of published data. Experimental part consisted in heating steel cylinders (0.48 C, 0.85 Mn, 0.34 Si, 0.039 S, 0.057 P) in a furnace with a condensed winding giving a gradual temperature interval 800°-1200°C. Specimens were heated to this temperature, held for 2, 3, and 7½ hours and cooled with the furnace at 15°/min.; heated to same temperature, soaked for 2 and 3 hours, quenched in water and drawn at 500°C.; uniform heating of the samples to 1200°C., soaking for 2 hours, quenching in water, drawing for 1 hour at temperatures ranging from 400° to 1000°C. and air cooling. There is a definite relation between the original shape and size of austenitic grains and the size and shape of the grains surrounded with ferritic mesh produced by recrystallization which is maintained for all heating temperatures and all heating time. The first indications of the presence of Widmanstätten structure could be seen on heating for 120 minutes at 800°C. as lamellae within the grains. They did not reach the ferritic mesh. At 1000°C. spurs of ferrite were seen at the boundaries. Typical Widmanstätten structure could not be produced at any temperature with this time of heating. Using 450 minutes heating, spurs can be seen well at 1000° and at 1200°C. typical Widmanstätten structure is produced, though not quite uniform. The appearance of spurs of ferrite and Widmanstätten structure is undoubtedly connected with the formation of large grain. At the junction of small and large grains, spurs grow only into the large grain. Large size of grains alone is not sufficient to cause this structure. Specimens of the same steel 280 mm. long were placed into cylindrical bore of a steel cone so as to change the cooling speed of the former. To increase the difference in the rate of cooling the cone with the sample was placed into a preheated resistance furnace after removal from the heating furnace. With the low heating temperature, 950°C., and slow cooling speeds 4°-10°C./min, the banded structure originally present in steel remains. Starting with 15°C./min cooling speed it is not observed any more. Under all experimental conditions ferritic mesh was observed, the thickness of which decreases with the cooling speed. The change in thickness was the more pronounced the lower the steel was originally heated. Lamellar crystals do not appear on heating to 950°C. With higher temperatures they appear at the lower cooling speeds the higher was the heating temperature. With 1050° and 1150°C. heating Widmanstätten structure is produced with any cooling speed tried (4° to 54°C./min). Apparently to every heating temperature corresponds a proper minimum speed of cooling, though the demarcation line is not drawn sharply. Decarburization induces the formation of Widmanstätten structure in the corresponding zones. Quenching from 1200°C. in water followed by drawing for 2 hours at 700°-1000°C. showed that specimens drawn under the critical give a typical Widmanstätten structure combined with ferritic mesh. Possible influence of strain at high temperatures was investigated by loading specimens at 830°, 1000°, and 1100°C. holding them at the temperature 40 and 320 minutes and cooling either at 8° or 50°C./min. Strain showed itself in the appearance of spheroidized pearlite, which decreases with the rising temperature. At 830°C. there is plenty of spheroidized pearlite in the structure, but the spheroidization evades larger grains, in which pearlite remains lamellar. At 1000°C. there is less spheroidized pearlite and it is mixed with lamellar. At 1100°C. it is totally absent. Time of heating helps the formation of spheroidized pearlite. The size of grains sharply increased in comparison with the similar samples subjected to identical temperature cycle but without strain. Lamellae of ferrite, when they are observed, are not limited to individual grains alone but are stretched through several grains in a continuous line. It might suggest that the space lattice of the grains in which continuous ferritic bands are observed become identical or at least closely resembling. This could be observed only with 240 min. heating time and 1100°C. temperature. (10)

Contraction of Aluminum and Its Alloys on Solidification (Contrazione dell'alluminio e delle sue leghe all'atto della solidificazione). I. L. Losana. *Alluminio,* Vol. 3, Nov.-Dec. 1934, pages 321-327. Change in volume of Al and some of its alloys during melting and freezing have been measured by the hydrostatic-balance method. The changes in volume caused by the addition of varying amounts of Fe, Si, and Cu were determined. The contraction in volume on solidification, which is about 6.1% for pure Al, is reduced to 5.95% and 5.6%, respectively, by 1 and 2% Fe. The contraction is reduced to 5.8, 5.2, and 4.6% by additions of 0.7, 1.4, and 1.6% Si; further additions up to 20%, the limit studied, reduce the contraction progressively. Cu reduces the contraction to 5.8, 5.4, 4.3, 3.6% by addition of 1, 2, 5, and 7% Cu, respectively. Further additions produce very little change. AWC (10)

Micrographic Study of the Structure and Hardness of an Ordinary 0.58 Carbon Steel After Quenching in Water, with Particular Attention to the Transitional Zone between the Annealed and Non-annealed States, after Heating or Cooling (Etude d'un Acier Ordinaire à 0.58 de Carbone au Point de Vue Micrographique et Dureté après Trempé à l'Eau, et, notamment, Etudé de la Zone de Transition entre Partie Trempée et Partie non Trempée après Chauffage ou Refroidissement, Dégradés). J. Seigle. *Chimie et Industrie,* Vol. 32, Oct. 1934, pages 773-782. The author studied the structural changes when a steel with at least 0.90% C is heated to a temperature between Ac_1 and Ac_3 and then quenched in water, as well as changes after the steel is heated to Ac_3 and allowed to cool in the furnace before quenching. This study shows the results obtained with an ordinary 0.58 C steel and the results are interpreted according to the new Fe-C diagram proposed by the author. He concludes: (1) It is possible that the solid solution does not have self-limiting grains, and hence is not homogeneous. (2) The solid solution is less stable when the steel has been heated beyond the Ac_3 point than when it has been heated a long time. (3) If heated slightly beyond Ac_3, a slow, normal cooling in the furnace will give a pearlitic structure with small grains. If heated 3/4 hr. at 950°, or several minutes at 1100°, large grains are produced. A mixture of both is obtained if the steel is heated between 900° and 925° and 950° for a reasonable time. (4) the heterogeneities which occur and are accentuated at the Ar_3 point are explained with the aid of the proposed Fe-C diagram. MAB (10)

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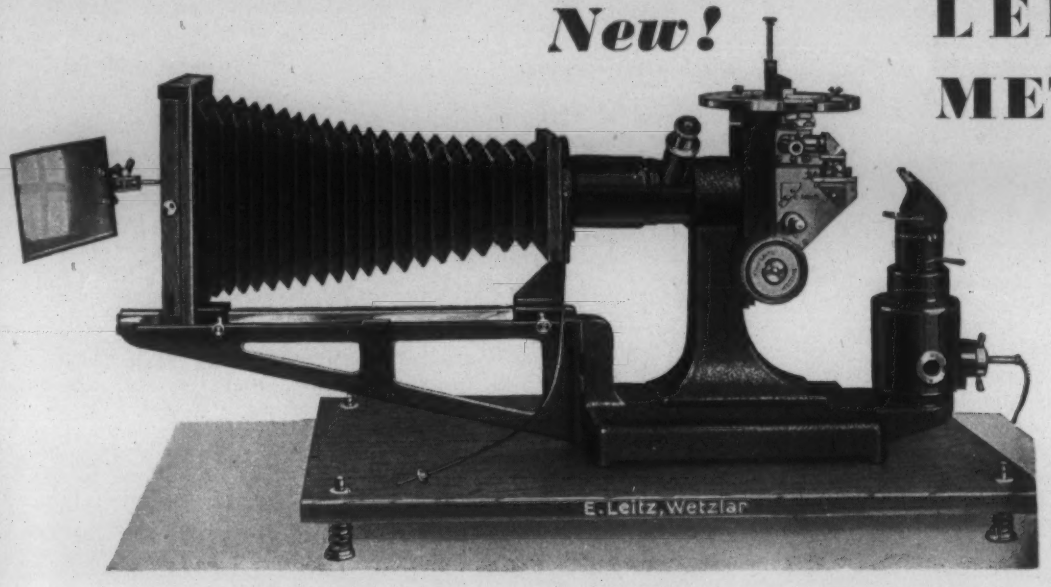

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The Constitution and Properties of Cadmium-tin Alloys. D. HANSON & W. T. PELL-WALPOLE. *Journal Institute of Metals*, Vol. 56, Advance Copy No. 686, Oct. 1934, 22 pages. Cd-Sn alloys were studied by thermal and microscopic methods. A eutectic is formed at 176° C. and 33% Cd. There is solid solubility at either end of the system but the exact course of solid solubility curves was not determined. Above 131° C., Sn holds between 5 and 6% Cd in solution, but at 131° C., 2 conjugate solutions are formed, which at 127° C. have the compositions 1.25 and 5% Cd. At this temperature, the one richer in Cd decomposes to form a eutectoid. This occurs in all alloys containing from 1.25 to 99.5% Cd. In alloys with from 40 to 90% Cd a slight transition, connected with a change of solubility of Sn in Cd, occurs at 170° C. Tensile strength and hardness of alloys containing up to 10% Cd were determined after different heat treatments. Alloys containing 5% Cd can be treated to have a permanent tensile strength of 5 tons/in.^{2} Cd has a marked refining effect on the grain size of Sn. After a reduction of 80% by rolling, the grain size of Sn was 1600 grains/cm.^{2} and 26,000 grains/cm.^{2} for the alloy with 1% Cd. Further additions of Cd had little effect on grain size. After annealing for 1 day at 160° C., Sn containing 5% Cd had a grain size of 48,000 grains/cm.^{2} 13 references. JLG (10)

Composition of Crystalline Amalgams of Zinc, Lead, Tin and Cadmium. HENRY H. HOSFORD. *Journal of Dental Research*, Vol. 14, 1934, pages 33-37. Crystalline amalgams containing 41-45% Zn, 63-65% Pb, 78-79% Sn and 15-16% Cd are obtained by immersing respectively Zn, Pb, Sn and Cd in Hg for several days. The existence of the compounds $HgPb_2$ and either Hg_7Cd_2 or Hg_3Cd is thus corroborated. Ag and Cu did not form crystals in Hg under the same conditions. WH (10)

Crystallite Orientation in a Polycrystalline Metal During Plastic Flow. R. E. GIBBS & N. RAMLAL. *London, Edinburgh & Dublin Philosophical Magazine & Journal of Science*, Vol. 18, Nov. 1934, pages 949-956. The plastic flow of a metal under constant stress is divided into 3 stages: an immediate extension; a flow of which the rate gradually diminishes with the time, called β-flow; and finally a flow of constant rate, or viscous flow. To elucidate the conditions of β-flow X-ray examination was made of stretched wires. It was found that, when a polycrystalline metal flows, the β-flow is connected with a rotation of the axes of the crystallites, which confirms observations made by other investigators. Ha (10)

Distortion of the Crystal Lattice of Alpha-Brass. W. A. WOOD. *Nature*, Vol. 133, Oct. 13, 1934, page 572. The powder diffraction lines from α brass are slightly displaced when the specimen is cold worked. CSB (10)

Conditions for Obtaining Widmanstätten Structure in Plain Carbon Steels. P. YALOVOI. *Stal*, Vol. 4, June 1934, pages 53-61; July 1934, pages 53-62. In Russian. Steels containing $< 0.6\%$ C tend to form Widmanstätten structure; those containing $> 0.6\%$ C do not. The temperature of pouring, rate of cooling, and size of the ingot do not influence its formation. Widmanstätten structure is destroyed by normalizing, but overheating or quick cooling after normalizing will cause the formation of "secondary" Widmanstätten structure. HWR (10)

6 **Formation of Metallic Hydrides by Atomic Hydrogen. II. Investigations of the Tantalum-hydrogen System (Bildung von Metallhydriden durch atomaren Wasserstoff. II. Untersuchung des Systems Tantal-Wasserstoff).** ERICH PIETSCH & HERBERT LEHL. *Kolloid Zeitschrift*, Vol. 68, Aug. 1934, pages 226-230. X-ray and thermal investigation of the system Ta-H showed that a new phase is formed when atomic H is in contact with metallic Ta. This phase is body-centered cubic, as is Ta. The lattice increases from 3.33 to 3.42 A.U. Besides this linking in principal valency fashion, a solid solution is formed on longer hydriding times. This is accompanied by an additional widening of the space lattice ($a_{max.} = 3.44$ A.U.). The Debye-Scherrer reflection lines become broader at the same time. EF (10)

7 **The Dendritic Structure and Its Effect on the Properties of Steel (Das Primärgefüge und seine Wirkung auf die Stahleigenschaften).** F. RAPATZ & H. POLLAK. *Stahl und Eisen*, Vol. 54, Nov. 22, 1934, pages 1201-1210. A correlated abstract. The primary dendritic structure influences the secondary or microstructure on slow cooling, but in faster cooling, as in normalizing, there is little relation between them. The primary structure may still be recognizable even after drastic reduction, as in sheet. Shrinkage cracks are more apt to occur in coarsely dendritic steel. Flakes are attributed to micro-segregation in the interstices of the dendrites and to cooling stresses, and they may, therefore, be obviated by a homogenizing heat treatment and by slow cooling. SE (10)

8 **X-ray Investigation in Electroplating (Röntgen-Feinstrukturuntersuchungen als Hilfsmittel der Galvanotechnik).** H. REININGER. *Metallwaren Industrie & Galvano Technik*, Vol. 32, June 15, 1934, pages 260-262; June 30, 1934, pages 283-285; Aug. 15, 1934, pages 360-362; Sept. 1, 1934, pages 383-384; Sept. 15, 1934, pages 409-410; Oct. 1, 1934, pages 427-429. Fundamentals of crystal structure determinations by X-rays. EF (10)

Multiple Laue Spots from Aluminum Crystals. A. KOMAR & W. OBUKHOFF. *Nature*, Vol. 133, May 5, 1934, page 687. See *Metals & Alloys*, Vol. 6, Jan. 1935, page MA 28. CSB (10)

9 **Modification of Aluminium-silicon Alloys (Über das Modifizieren der Aluminium-Silizium-Legierungen).** JU. A. KLJATSCHKO. *Kolloid Zeitschrift*, Vol. 69, Nov. 1934, pages 215-218. The alloys of Al-Si recently gained considerable commercial significance due to their corrosion stability, low specific gravity, and excellent casting properties. However Al-Si alloys attain their maximum physical properties only if they are submitted to the "modification" process which consists of addition of small amounts of K, Na, (0.1% max.) or their fluorides. The modification phenomenon, which induces a finely crystalline structure has been theoretically interpreted in various manners, namely, as a deoxidation 1(phenomenon, as formation of a special ternary alloy, and on (two) dispersion grounds. The author's tests proved that modified silumin contains a smaller quantity of Si in solid solution than the normal Al-Si alloy. The effect on metals and alloys of minute quantities of contamination is pointed out and the application of the science of "disperseology" to metallurgical problems is urged. EF (10)

The Carbides in Steels with Low Vanadium (Die Karbide in Stählen mit niedrigem Vanadingehalt). W. Bischof. *Archiv für das Eisenhüttenwesen*, Vol. 8, Dec. 1934, pages 255-258. By means of electric resistance measurements of annealed and of quenched V steels—C from 0.16 to 1.07%, V from 0.91 to 2.18%—and by electrolytic separation of the carbides, it was established that in low C steels V_4C_3 is present adjacent to the cementite, and in higher carbon steels, VC. Curves are shown indicating the relative amounts of cementite and of the V carbides in the steels studied, according to the following examples.

Composition	C as cementite	C as V carbide
1% V, 0.2% C	0.04%	0.16% as V_4C_3
1% V, .5% C	.26%	.24% as VC
2% V, 0.6% C	.1%	.5% as VC

SE (10)

The Transformation Mechanism from Body-centered-cubic to Close-packed-hexagonal Zirconium. Connection with the Modifications of Calcium (Der Übergangsmechanismus von kubisch-raumzentriertem in hexagonal dichtest gepacktes Zirkon. Zusammenhänge mit den Modifikationen des Kalziums). W. G. Burgers. *Metallwirtschaft*, Vol. 13, Nov. 9, 1934, pages 785-786. The transformation of β body-centered-cubic into α close-packed-hexagonal Zr at about 870°C. takes place through a combination of shifts and dilatations parallel to definite crystallographic directions and not through grain growth. The relative orientation of the crystals is such that it would be possible for an intermediate phase, face-centered cubic, to have formed. This phase was not found in the case of Zr, but it is possible that the occurrence of both the close packed hexagonal and body-centered phases in Ca above 450° can be explained in this way. A schematic illustration of the transformation shift of the 3 phases is given. CEM (10)

Orientation of Oxide Films on Metals. R. F. Mehl, E. L. McCandless & F. N. Rhines. *Nature*, Vol. 134, Dec. 29, 1934, page 1009. Wüstite, "FeO," was found to form on single crystals of purified iron with a simple orientation related to the orientation of the iron (cube planes parallel in the 2 phases, but cube axes inclined 45°). The oxidation was performed at 700°C. in a mixture of H_2 and H_2O vapor. Cuprous oxide forms on a single crystal of Cu with an orientation such that the cube axes in both phases are accurately parallel; as the oxide layer thickens the perfection in orientation is gradually lost, becoming random when the thickness is about 0.002". CSB (10)

An Ultra Violet Microscope for the Examination of Opaque Objects. B. K. Johnson. *Journal of Scientific Instruments*, Vol. 11, Nov. 1934, pages 384-394. This paper describes work which has led up to the design of a special form of microscope for the examination of opaque specimens in the ultra-violet. Design of the optical system, the ultra-violet transmission of suitable materials, the ultra-violet reflecting power of certain metals, the fine adjustments, and the instrument in use are described. This instrument is said to be particularly useful in the field of ultra-violet metallography. RAW (10)

The Mechanical Behaviour of Single Crystals of Mercury. E. N. da C. Andrade & P. O. Hutchings. *Proceedings of the Royal Society*, Vol. 148, No. 863, Series A, Jan. 1935, pages 120-146. Single crystals of Hg are especially easy to prepare; purification of the metal is easier than for any other metal. Hg was distilled in a quartz still in vacuo. Crystals were obtained by freezing a glass tube of Hg in a bath of alcohol plus CO_2 snow, the tube being lowered into the bath by clock-work mechanism. Single-crystal wires so produced were subjected to stretching without torsion or bending while being maintained below —38.8°C. (Hg m.p.). Other operations at this temperature were: rotating wire about its axis for observation of gliding, photographing the wire through microscope, and measuring the stretching force. Testing apparatus is partially shown. Slip bands are formed in wire with the slightest stretching. Parallel lines intersecting wire surface show location of slip planes. Determined were: glide planes, glide directions, and twinning planes for the rhombohedral. Hg single crystal. Rhombohedral faces are glide planes and the short diagonal is the glide direction. When strained, twinning takes place on a plane through the long diagonals of two opposite faces which act as glide planes. The rhombohedral face and the hexagonal basal plane are equally close packed, but the former contains a much more closely packed line than the latter. Hardening on one set of glide planes hardens the whole crystal. Photographs of the gliding planes and twins are shown. WB (10)

Mechanical Strength Properties and Actual Structure of Crystals (Die mechanischen Festigkeitseigenschaften und die Realstruktur der Kristalle). E. Orowan. *Zeitschrift für Kristallographie*, Sonderheft "Ideal—& Realkristall," Vol. 89, Oct. 1934, pages 327-342. The physical properties of plastic materials such as metals and in particular plastic flow and rupture cannot be qualitatively or quantitatively interpreted under the assumption of a completely homogeneous space lattice. The existence of these "lability" phenomena cannot be taken as a basis for interpreting the continuous and periodic deviations of the structure of real crystals from the ideal lattice since these phenomena occur, in principle, in the same fashion in amorphous materials. The rupture and flow theory of Griffith (*Philosophical Transactions of the Royal Society of London*, Vol. 221, Mar. 1921, pages 163-198) furnishes a satisfactory basis for interpreting the physical strength properties of metallic crystals and all hypotheses going beyond Griffith's theory (block-structure,—secondary structure—and Smekal's "Lockerstruktur" hypothesis) are rejected. EF (10)

Transformations in Homogeneous Materials (Über Umwandlungen in homogenen Stoffen). G. Tammann. *Zeitschrift für physikalische Chemie*, Abt. A, Vol. 170, Nov. 1934, pages 380-390. The transformations in crystalline materials can be classified into 2 main groups depending on whether the transformation is accompanied by recrystallization or if the transformation takes place while the crystal remains homogeneous. In the former, the physical properties must change in a discontinuous manner at a certain temperature. But if no recrystallization takes place, the properties change gradually over temperature ranges. There is a third group of materials which undergo transformations falling between both principal types of transformations. The primary reaction in all of the 3 transformations is due to phenomena taking place in the atoms or molecules depending on whether or not the sphere of influence renders the space lattice unstable. The theoretical deductions are checked on experimental evidence referring to changes of ferromagnetic properties (Ni, Fe), of heat contents, and of linear dimensions (β-brass) during transformations. EF (10)

New Etching Reagent for the Examination of Micro-Structure (Neues Aetzmittel für die Grobgefügeuntersuchung). A. Matting. *Autogene Metallbearbeitung*, Vol. 27, Nov. 15, 1934, pages 353-355. A solution of 25 cc. distilled water, 3 g. copper-ammonium chloride, 50 cc. HCl (1.19 sp. gr.), and 15 g. iron chloride, is used; it is especially good for high-C steels as the Cu precipitate is easily removable. Ha (10)

Softening of a Deformed Crystal During Recovery (Die Entfestigung eines deformierten Kristalls bei der Erholung). M. Kornfeld. *Physikalische Zeitschrift der Sowjetunion*, Vol. 6, No. 4, 1934, pages 329-342. The rate of softening of single crystals of Al has been studied in relationship to the degree of deformation and temperature of recovery. An exponential function—though not definitely established—is assumed to link these properties. The interrelation between yield point and recovery temperature previously reported (see *Physikalische Zeitschrift der Sowjetunion*, Vol. 5, No. 2, 1934, pages 185-190) was studied further over a wide range of deformation. It could be proved that a second abrupt drop of the yield point occurs with annealing temperatures above 550°C., which temperature range completely restores the initial properties of the Al crystals. It has been established that the strain hardening coefficient of a deformed crystal changes with the recovery temperature in such a manner that the strain hardening coefficient is lowered by working and subsequent annealing. The strain hardening coefficient increases when the temperature of recovery is raised from 100°C. to 400°C. The phenomenon of recovery takes place only in severely distorted space lattices and is restricted to crystal boundaries contrary to the phenomenon of recrystallization. A shifting of the yield point cannot be explained plausibly since the nature of strain hardening has not been interpreted satisfactorily so far. EF (10)

Theory of Undercooled Solid Solutions (Zur Theorie der unterkühlten festen Lösungen). S. Konobejewski. *Zeitschift für physikalische Chemie*, Abt. A, Nov. 1934, pages 25-35. Based on the theory of undercooling the stabiilty of solid solutions and some problems of segregation in solid solutions are discussed. The accelerating effect of elastic (residual) stresses on the decomposition speed of metallic solid solutions is pointed out. The metastable state of undercooled solid solutions, if undisturbed, may be maintained almost indefinitely. The mathematical treatment of the subject is supported by experimental evidence gathered by the author and his coworkers on the α-phase boundary line in the Cu-Sn system after cold working, the precipitation of Si in Al-Si and the eutectoid disintegration of deformed Mn steel (10% Mn, 1% C). The later unpublished experiments by Konobejewski & Gorjanow show that the decrease of the lattice constants of austenite takes place in 2 steps on annealing at 400°-500°C. After longer or shorter annealing times, depending on the temperature (400°C.=15 min., 450°=1½ min., 600°=instantaneously) a spontaneous space lattice change takes place which corresponds to a highly dispersed formation of new ferrite-cementite crystals. On further annealing a gradual change of the lattice constants occurs which is attributed to the coagulation of the nuclei due to the diffusion process. The phenomena preceding the actual precipitation and the problem of orientated precipitation (Widmanstätten structure) are theoretically dealt with. EF (10)

A Graphical Indexing Method for Rotating Crystal Photographs (Ein graphisches Indizierungsverfahren von Drehkristallaufnahmen). N. J. Seljakow & E. I. Sows. *Zeitschrift für Kristallographie, Kristallgeometrie, Kristallphysik, Kristallchemie*, Vol. 89, Dec. 1934, pages 601-606. A graphic method is advanced for indexing X-ray photographs taken on crystals which rotated around an arbitrary axis. The use of the graphic method is demonstrated by X-ray films of single crystals of Al. EF (10)

Group Phenomena in Metallic Crystals (Gruppen-Phänomene in Metallkristallen). Alexander Goetz. *Zeitschrift für Kristallograhie*, Vol. 89, Sonderheft "Ideal & Realkristalle," Oct. 1934, pages 310-326. Survey of the experimental evidence which describes and interprets the differences between ideal and real crystals yields the conclusion that the assumption of molecular aggregates of equal size or of unit blocks offers the most plausible explanation for the occurrence of periodic phenomena of higher order in metallic crystals. EF (10)

Some Fundamentals of the Microstructure of Metals. P. F. Harrop. *Mechanical World & Engineering Record*, Vol. 96, Sept. 21, 1934, pages 267-268. Application of photomicrographs in the presentation of data on metals and alloys and their heat treatment. Kz (10)

Investigation of Magnetic Properties in Relation to Precipitation Hardening in Fe-Ni Alloys (Magnetische Untersuchungen an Ausscheidungsfähigen Eisen-Nickel-Legierungen). F. Preisach. *Zeitschrift für Physik*, Vol. 93, Jan. 4, 1935, pages 245-268. Magnetic properties, including magnetization curves, permeability and coercive force, of 2 alloys were studied, one with 55% Ni, 45% Fe and about 0.5% Be, the other 38% Ni, 46% Fe, 15% Cu, 1% Mn. Results were correlated with hardness and electric-resistance for both cold-worked samples and those subjected to various annealing temperatures. FHC (10)

Foundry Committee, Communications of the Deutsche Gesellschaft für Metallkunde (Giessereiausschuss, Mitteilungen der Deutschen Gesellschaft für Metallkunde). Kohlmeyer. *Zeitschrift für Metallkunde*, Vol. 26, Aug. 1934, pages 191-192. A review of the constitution, microstructure and physical properties of oxygen-bearing Cu containing impurities of Ni, Sn, Sb, As, Bi and Pb. FNR (10)

Independence of Grain Size and Dendrite Fineness. Ichirô Itaka. *Bulletin Institute of Physical & Chemical Research, Tokyo*, Vol. 13, Dec. 1934, pages 1395-1400. In Japanese. *Abstracts of the Bulletin of the Institute of Physical & Chemical Research, Tokyo*, Vol. 13, Dec. 1934, page 81. In English. Grain size (defined as the mean diameter of the crystals) and dendrite fineness (= mean distance between the dendrite branches) were investigated in gun metal, bronze, Al bronze (5% Al), brass (20% Zn) constantan and an Al alloy containing 5% Mg. The alloys cast at different temperatures were studied in the sand- and chill-cast state. In the latter case, the molds were preheated to different temperatures. In some cases the alloys passed the freezing in range in ½-2 hours. In 4 cases, grain size was proportional to dendrite fineness. In 6 cases, dendrite fineness changed while grain size remained constant. Grain size was found three times to be inversely proportional to dendrite fineness and in 2 cases dendrite fineness remained constant while grain size changed. It is concluded that there is no functional relationship between grain size and dendrite fineness. WH (10)

Practical Use of the X-Ray Back-Reflection Method for Measuring Elastic Stresses (Praktische Anwendungen des Röntgen-Rückstrahl-verfahrens zur Messung elastischer Spannungen). H. Möller. *Archiv für das Eisenhüttenwesen*, Vol. 8, Nov. 1934, pages 213-217. Internal stresses cause a change in the lattice parameter. An X-ray back-reflection method for determining these stresses is described. An advantage of the X-ray over the mechanical methods usually employed is that it gives the absolute value of the stresses and not merely differences. However only the stresses at the surface can be measured and variations in composition and cold work may affect the results. SE (10)

Alpha-gamma Inversion of Iron. W. D. Jones. *Iron & Coal Trades Review*, Vol. 129, Oct. 5, 1934, page 505. See "The Influence of Diffusing Elements upon the Alpha-Gamma Inversion of Iron," *Metals & Alloys*, Vol. 5, Dec. 1934, page MA 580. Ha (10)

New Phase Transformations in Homogeneous Media (Neuartige Phasenumwandlungen bei einheitlichen Stoffen). E. Justi & M. von Laue. *Sitzungsberichte der Preussischen Akademie der Wissenschaften, Mathematisch-naturwissenschaftliche Klasse*, Vol. 23, June 7, 1934, pages 237-249. Discussion of various transformation phenomena on thermodynamic grounds which differentiates transformations of first, second, and third order. Transformations of the first order involve allotropic lattice changes, whereas the third group refers to transformations characteristic of β brass. The (hitherto unknown) second type of transformation is evolved theoretically. WH (10)

The ϵ, γ, δ and β Phases of the System Cadmium-silver. P. J. Durrant. *Journal Institute of Metals*, Vol. 56, Advance Copy No. 685, Oct. 1934, 12 pages. Cd-Ag alloys containing from 30 to 60% Ag were investigated by thermal and microscopic methods. In this region the liquidus consists of 4 smooth curves intersected by peritectic horizontals at 592, 640, and 736°C. The boundaries of the ϵ, γ, and β phases were determined. No changes occur below the solidus in the ϵ and γ phases, but β undergoes 2 transformations. The upper transformation $\beta \rightleftarrows \beta'$, occurs at 470°C. when γ is present, at 440°C. when α is present, and at some intermediate temperature when β alone is present. The lower transformation, $\beta' \rightleftarrows \beta''$ occurs at 230 or 240° C. or at some intermediate temperature under the same respective conditions. Both of these transformations are associated with marked changes in the range of solid solubility, and with the existence of eutectoid points at which the solid solution decomposes into a characteristic duplex structure of the Widmanstätten type. 5 references. JLG (10)

X-ray Investigations of Zinc-nickel Alloys (Richerche roentgenografische sulle leghe Zn-Ni). Vincenzo Cagliotti. *Atti del congresso nazionale di chimica pura ed applicata*, Vol. 4, 1933, pages 431-441. An X-ray study of the Ni-Zn system was made covering the range 0-53% Ni. At 5% Ni, faint indication of a phase, designated as ϵ phase, was found, but not structurally determined. A homogeneous γ phase was found to extend from 15-22% Ni and at 46% Ni a β phase and at 53% Ni a phase of the same structural type as cubic α Ni were found. No solubility of Ni in the Zn lattice could be proved. The body-centered-cubic γ phase corresponds to Ni_5Zn_{21}. This phase forms solid solutions with both Ni and Zn. The eutectic of the γ and β phase was located at 40% Ni. The β phase, which corresponds to NiZn according to the Hull system can be regarded as tetragonal with $c/a = 0.83$, which corresponds to γ Mn or AuCu with $a_o = 3.867$ A.U. and 4 atoms in the elementary cell (Zn = 0 0 0, ½ ½ 0, and Ni = ½ 0 ½, 0 ½ ½). EF (10)

Alloys of Praseodymium and Copper (Le leghe tra praseodimio e rame). G. Canneri. *La Metallurgia Italiana*, Vol. 26, Nov. 1934, pages 869-871. A thermal and micrographic study of the system Pr-Cu was made. The existence of the following compounds has been shown: $PrCu_6$, melting at 962°C.; $PrCu_4$, with a transition temperature of 824°C.; $PrCu_2$, melting at 841°C.; and PrCu, transition temperature 563°C. There are also 3 eutectics containing 17, 46, and 82% Pr. The alloys are all hard and fragile. AWC (10)

Flakes in Ball Bearing Steel. V. Chernishoff. *Heat Treating & Forging*, Vol. 20, Sept. 1934, pages 445-446. In addition to dendritic segregation on solidification of the ingot, formation of flakes in 1.1%C and 1.2% Cr ball-bearing steel may be induced by intense overheating (above 1150°C.) before forging or rolling. The defect may result from the heterogeneity in microstructure which occurs when the hypereutectic carbides are transformed into a solid solution, which can take place only when the temperature at the end of the forging period is low. Formation of flakes may be avoided by increasing the rate of forging, which results in a more intense mixing of the structural constituents. MS (10)

X-Rays—What Should We Know About Them? Geo. L. Clark. *Electrical Engineering*, Vol. 54, Jan. 1935, pages 3-14. Nature of rays and industrial applications. Ha (10)

Microscopic Study of Phosphoric Irons (Contribution a l'Étude Microscopic des Fontes Phosphoreuses par la Méthode de Stead-Kunkele). R. Colas. *Bulletin de l'Association Technique de Fonderie*, Vol. 8, No. 9, Sept. 1934, pages 429-431. Specimens were photographed in colors. WHS (10)

The National Physical Laboratory. *Engineering*, Vol. 138, Oct. 5, 1934, pages 362-364. Summary of the tests carried out in the Laboratory on the use of X-rays in metallurgy. LFM (10)

A.S.M. Grain Size Symposium Records Recent Progress. *Steel*, Vol. 95, Oct. 22, 1934, pages 34, 36, 38-39; Oct. 29, 1934, pages 33-36, 43; Nov. 5, 1934, pages 34, 36, 38. Abstracts and discussion. MS (10)

Susceptibility Measurements of Solid Solutions of Aluminum (Suszeptibilitätsmessungen an Aluminiummischkristallen). H. Auer. *Zeitschrift für Physik*, Vol. 92, Nov. 26, 1934, pages 283-290. Variations in susceptibility of pure Al and Al solid solutions show that this characteristic is an additive function of the amount of the solute. FHC (10)

Microscopic Examination of Iron-Tin Reaction Products. W. D. Jones & W. E. Hoare. *Sheet Metal Industries*, Vol. 8, Oct. 1934, pages 571-572. See *Metals & Alloys*, Vol. 5, Oct. 1934, page MA 490. AWM (10)

Twin Formation in Graphite Crystals (Zwillingsbildung bei Graphitkristallen). W. S. Wesselowski & K. W. Wassiliew. *Zeitschrift für Kristallographie*, Vol. 89, Nov. 1934, pages 494-496. X-ray study of cast-Fe and natural graphite from the Zawalje district. EF (10)

1 **Principles of Heat Treatment.** R. G. Williams. *Heat Treating & Forging*, Vol. 20, Aug. 1934, pages 377-381; Sept. 1934, pages 440-444. Elementary outline of the metallography of C steel for practical heat treaters. MS (10)

— **Structure of Metals. V. The Effect of Welding on the Plate.** E. C. Rollason. *Welder*, Vol. 6, Oct. 1934, pages 341-343. The changes in a piece of annealed steel plate on heating to different temperatures and the effects of cold working are briefly discussed. Ha (10)

2 **The Influence of Grain-size on Magnetic Properties.** W. E. Ruder. *Transactions American Society for Metals*, Vol. 22, Dec. 1934, pages 1120-1141. With discussion. See *Metals & Alloys*, Vol. 5, Nov. 1934, page MA 533. WLC (10)

— **Determination of Orientations of Metallic Crystals by Means of Back-reflection Laue Photographs.** Alden B. Greninger. *Metals Technology, American Institute Mining & Metallurgical Engineers, Technical Publication* No. 583, Dec. 1934, 11 pages. Back-reflection Laue photographs are suitable for determining orientation of opaque crystals. When applied to the cubic system, only one photograph is needed. The symmetry of the spots is discussed and directions are given for interpretation of the photographs. A hyperbolic angular-coordinate plat, shown as a figure, is recommended for analyzing the photographs.

3 JLG (10)

— **X-ray Determination of the $FeAl_3$ Structure (Röntgenographische Bestimmung der $FeAl_3$ Struktur).** E. Bachmetew. *Zeitschrift für Kristallographie, Kristallgeometrie, Kristallphysik, Kristallchemie*, Vol. 83, Dec. 1934, pages 575-586. Object of this investigation was analysis of the phase in the Fe-Al system which forms first in Al on alloying Al and Fe. 17 references to previous work on $FeAl_3$ are summarized. The author found by 4 methods that $FeAl_3$ belongs to the rhombic system and has the following lattice constants: $a = 47.43$ A.U.; $b = 15.46$ A.U.; $c = 8.08$ A.U.; space group = V_h^{28}; number of atoms/unit body = 400, calculated density = 3.811.

4 EF (10)

— **Evaluation of Inhomogeneities in Solid Solutions.** Albert Portevin. *Metal Progress*, Vol. 27, Feb. 1935, pages 42-43. Suggests "topographic mapping" of alloy surfaces with "contours" which are "iso-chemical" for the study of variations in solid solution compositions and their probable effect upon such phenomena as intergranular corrosion of stainless steels. WLC (10)

5 **The Diffraction of X-rays and Electrons by Amorphous Solids, Liquids and Gases.** J. T. Randall. John Wiley & Sons, Inc., New York, 1934. Cloth, 5¾ x 8¾ inches, 290 pages. Price $5.75.

— The progress of X-ray diffraction studies has been from first the highly organized state of matter, the single crystal, to the disorganized states. The field of this book embraces small crystallites and other less organized states of matter.

After a concise treatment of the elementary principles of X-ray crystallography, the effects peculiar to minute crystals are discussed, and the determination of

6 crystal size explained.

The scattering of X-rays by gases is shown to provide information from which atomic and molecular structures can be determined. By the use of electron beams

— still further information can be secured on gases. With liquids a surprising amount of information can be secured. Evidence of atomic arrangement and distances, and the length and thickness of molecules can be secured. Similar information can be obtained for solids which are microscopically amorphous.

Of greatest potential value to metallurgy is the determination of the structure of surface layers. Here electron diffraction methods eventually may prove superior to X-ray methods, as films too thin for investigation by X-rays can be studied. The study of polished surfaces is of interest as the results present evidence for

7 the existence of an amorphous state in metals.

The book is well written with a nice balance between the theoretical and experimental aspects of the problem. It will be welcomed by all interested in the broad applications of diffraction phenomena to the study of the structure of materials . H. W. Russell (10) -B-

— **Some Statistical Properties of an Annealed Alpha-grain Aggregate: Part III.** R. G. Johnston & W. G. Askew. *Metal Industry*, London, Vol. 45, Sept. 7, 1934, pages 219-221. The authors present two methods of measuring the

8 "mean intercepts" of grains in an endeavor to develop a rational method of grain-pattern specification. Tentative suggestions are offered which, they believe, may afford a foundation of knowledge about the nature of patterns that might be used in the development of specifications. They believe it is necessary that the largest max. diameter to be tolerated in a half or quarter-plate field at 100X and the max. and min. limiting values of the mean intercept be stated. With

— these as a basis they think considerable progress in this field may be made. HBG (10)

X-ray Studies of the System Fe-Cr-N (Röntgenundersökningar över systemet järn-krom-kväve). Sten Eriksson. *Jernkontorets Annaler*, Vol. 118, Nov.

9 1934, pages 530-543. Fe-Cr nitrides were prepared by passing NH_3 over the heated alloys. An intermediary phase (α') of the formula Fe + Cr was confirmed, and is probably to be considered as a deformed α lattice. The symmetry, however, is low and either tri- or monoclinic. In the Cr-N system the hexagonal

— β phase was found to have a "super structure," with a volume three times that of the close-packed hexagonal lattice. The length of the c axis is the same for both cells but that of the a axis is 1,732 times that of the close-packed lattice. The homogeneity limits are 11.9% to 9.3% N. The dimensions range from $a = 4.750$ A.U. (2.742 A.U.), $c = 4.429$ A.U. (4.429 A.U.) and $c/a = 0.933$ (1.615) at the lower limit to $a = 4.796$ A.U. (2.769 A.U.), $c = 4.470$ A.U. (4.470 A.U.) and $c/a = 0.932$ (1.614) at the upper limit, the

10 numbers in parentheses referring to the hexagonal-close-packed cell. HCD (10)

Panphot, a New Camera-Metal Microscope (Panphot, ein neues Kamera-Metallmikroskop). Hugo Freund. *Giesserei*, Vol. 22, Feb. 4, 1935, pages 57-59. Descriptive. Ha (10)

11. PROPERTIES OF METALS AND ALLOYS

A New Apparatus for Determination of the Heat Conductivity of Metals. N. D. Tomashow & J. B. Fridman. *Transactions of the Scientific Research Institute of Aircraft Materials (Trudy Vsesoiuznago Nauchno-Issledovatel'nago Instituta Aviatsionnykh Materialov)*. No. 8, 1934, 20 pages. In Russian. The paper is divided into 2 parts. The first part deals with the classification and review of the methods for determining heat conductivity of metals and alloys. In the second part the authors describe their apparatus which was constructed to study the heat conductivity of metals within the range 0° to 200° C. The specimens used are round bars 12 mm. diameter and 260 mm. long. The difference in temperature is maintained by means of a heating element placed inside of one end of the specimen and cooling other end of the specimen with water. The amount of the heat energy passing through the bar per unit time can be determined by measuring (a) the electrical energy consumed in heating and (b) the quantity and increase in temperature of water consumed for cooling. The apparatus is constructed on the principle of an absolute determination of heat conductivity in the steady state of a test bar. To limit heat losses a protective cylinder was used. In order to determine these losses the apparatus was calibrated with a specimen made of a material (cork) having a very small heat conductivity. The temperatures were measured with a series of Nichrom-Constantan thermocouples. It was found that accuracy of this device is around 3%. A series of metals (aluminum, Y alloy, pearlitic steel, etc.) possessing different heat conductivities were examined. The results obtained by the authors were in close agreement with those obtained by other investigators. AIK (11)

Hooke's Law Amended. R. W. Carson. *Instruments*, Vol. 7, June 1934, pages 109-112. Detailed study of aging and lag effects with particular reference to instrument springs, in the use of which the assumption of linearity must be discarded. Author presents a long list of "true moduli" for frequently-used elastic metals and alloys based on Sayre's formula for "true modulus." Characteristics of aging and lag are set forth. An imposing list of terms is assembled, most being re-defined. Aging is shown to be independent of load and to be caused by internal stresses. Author discloses for first time the following heat treatments to minimize internal stresses;

Spring material	*Temp.*	*Time*	*Spring material*	*Temp.*	*Time*
Phosphor bronze	100°C.	15 hrs.	Low C steel	200°C.	5 hrs.
Hard drawn brass	120°C.	10 hrs.	Low alloy steel	200°C.	5 hrs.
Hard drawn Ni	150°C.	8 hrs.	Music wire	300°C.	5 hrs.
Ni Ag	150°C.	8 hrs.	High C steel	300°C.	5 hrs.
Monel Metal	150°C.	8 hrs.	Ni steel	300°C.	5 hrs.

(Abstractor can report above to have greatly improved performance of two instrument manufacturer's springs). Experiments are reported indicating lag to be influenced by time and by load, author's specially-designed ultra-micrometric curve-drawing instrument being briefly described. Numerous other investigations are reported. MFB (11)

Contribution to the Problem of Classification of Elements in the Periodic System (Quelques remarques au sujet de la classification périodique des éléments). M. Lemarchands & M. Jakob. *Bulletin de la société de France*, Vol. 5, Aug. 1934, pages 1070-1075. The chemical energy of an element is considered to be the sum of 2 properties, namely its metallic or metalloid energy and its oxidizing or reducing energy. These 2 different items are evaluated for 41 more important elements of the periodic system, for which a series of values result which express numerically the chemical properties of the elements. The consistent variation of the properties of metals and metalloids is particularly striking and the unique behavior of C is interpreted on the basis of its special place in this periodic arrangement of the authors. EF (11)

Compression of Metals through Formation of Intermetallic Compounds (Kompressionen der Metalle bei der Bildung intermetallischer Verbindungen). Wilhelm Biltz. *Zeitschrift für Metallkunde*, Vol. 26, Oct. 1934, pages 230-232. The volume contraction, upon combining, of an extensive list of intermetallic compounds is compared, whereby it is shown that: (1) the total contraction can be resolved into increments of contraction which are characteristic of the individual elements; (2) the increments of contraction of the noble metals are small, while those of the base metals are large; (3) the metals of high compressibility, and large electronic volume, contract most upon combining. FNR (11)

11a. Non-Ferrous

A. J. PHILLIPS, SECTION EDITOR

Alloying Characteristics of the Elements Be, Mg, Zn, Cd, Hg, Al, Sn (Legierungseigenschaften der Elemente Be, Mg, Zn, Cd, Hg, Al, Sn). U. Dehlinger. *Zeitschrift für Elektrochemie*, Vol. 41, Jan. 1935, pages 20-23. The mutual relations of these elements in the constitutional diagrams of their alloys are given in a table which summarizes the effects of the atomic radii of the individual atoms and the atomic radii differences in conjunction with a general survey of the appearance of compounds in the diagram, their structure and solubility or homogenizability. The table is set up in order to determine mutual alloying affinities and thus discover a new alloy group which can be tabulated as are the metals of group I (Cu, Ag, Au, Fe-metals, Pt-group) by means of the Hume-Rothery rule. Intermediate phases, according to the table, occur only with Mg, the compounds $MgCd_3$ and $CdMg_3$ should show strong affinity even in solid solution. The compound formation of Mg with Zn, Sn, and Al with Mg, Zn are discussed with respect to the table. The rules set up show the conditions of mutual alloying governed by the atomic radii differences and the polarizability of the atoms involved. In some cases the electron configuration of the atom involved upsets the rule and the table becomes of less value because the composition of a phase is not determined wholly by the atomic radii differences and polarizability. WB (11a)

Magnetic Investigation of the System Cobalt-Palladium (Magnetische Untersuchungen im System Kobalt-Palladium). G. Grube & O. Winkler. *Zeitschrift für Elektrochemie*, Vol. 41, Jan. 1935, pages 52-60. Tests were made to check the constitutional diagram obtained by thermal analysis in the ferromagnetic region, by magnetometer measurements. A special magnetometer was built to measure the intensity of magnetization at various temperatures. The apparatus is shown with special Pt wound furnace for heating rod-specimens of Co-Pd. Magnetization-temperature curves obtained are shown for various alloys from pure Co up to 90 atomic % Pd. The Curie temperature and the $\alpha \longrightarrow \beta$, $\beta \longrightarrow \alpha$ transformation points were observed for the alloys, and are given in tables and curves. The Curie point temperature of the β phase decreases steadily with increasing Pd. The pure Co and the 5 and 10 atomic % Pd alloys were the only ones showing a transformation above room temperature during heating and cooling. This transformation is similar to that found in the stable Fe-Ni alloys. A continuous series of β solid solutions can be assumed up to at least 90 atomic % Pd. WB (11a)

Highly Heat-Resisting Chromium-Aluminum-Iron Alloys (Ueber hochhitze beständige Chrom-Aluminium-Eisen-Legierungen). A. Grunert, W. Hessenbruch & K. Schichtel. *Elektrowärme*, Vol. 5, Jan. 1935, pages 2-11. A thorough investigation of Cr-Al-Fe alloys shows that their properties differ considerably from those of the Cr-Ni alloys and that they are much more resistant in high temperatures, especially in oxidizing atmospheres and those containing C and S. The reason is seen in the difference of the fine structure of the 2 alloys: while the Cr-Ni alloys are austenitic and have a face-centered cubic lattice, the Cr-Al-Fe alloys have a space-centered cubic lattice. The Cr-Ni alloys are pronouncedly sensitive at the grain boundaries, corrosion attack usually starts at these places. The Cr-Al-Fe alloys are not at all sensitive in this respect, even if precipitations deposit on the grain boundaries; oxidation proceeds uniformly over the whole grain. Above 1200° C., Cr-Al-Fe alloys are decidedly superior to Cr-Ni alloys and constitute an element of great usefulness in industrial furnaces with normal, oxidizing atmospheres. Examples illustrate how to select between the 2 types for temperatures below 1200°C. The following alloys were tested:

Composition	Life at 1200°C.	Remarks
30 Cr 1 Al remainder Fe	15 hrs.	
30 Cr 2 Al " Fe	15.5 "	
30 Cr 3 Al " Fe	32.5 "	
30 Cr 5 Al " Fe	35 "	
30 Cr 8 Al " Fe	26 "	
30 Cr 12 Al " Fe	— "	not workable
20 Cr 5 Al " Fe	11 "	
40 Cr 5 Al " Fe	26 "	
50 Cr 5 Al " Fe	— "	not workable
60 Cr 5 Al " Fe	— "	not workable

Additions of C up to 0.6% showed a considerable deterioration of the life, while P and S up to 0.1% did not exert a harmful influence. The alloys should therefore be made of materials as free as possible of C and under conditions excluding a C absorption. Additions of Co and Ni did not improve the properties; the latter makes the alloy especially difficult for working. 10 references. Ha (11a)

Special Copper-Nickels (Les Cupro-Nickels spéciaux). L. Guillet. *Cuivre et Laiton*, Vol. 7, Dec. 30, 1934, pages 585-587. Simultaneous addition of Ni and Si to Cu renders the latter susceptible to heat-treatment; an alloy of 70% Cu with 30% Ni showed with different percentages of Si the following properties:

Si content %	Brinell Hardness after casting	heated to 150° and cooled slowly	quenched in water at 950° without reheating	annealed at 625° for 30 min.	annealed at 625° 3 hrs.
0	103	102	104	97	103
2	148	132	134	139	137
4	285	253	157	262	269
6	389	383	322	450	407

Other tests were made with 80% Cu and 20% Ni and up to 0.68% Si with results not so clear cut as before. An alloy of 33-35% Cu, 54-50% Ni and 13-15% Sn has a hardness of 250-320 and resists well the action of superheated steam. Alloys of 30% Cu, 64% Ni, 3% Sn, 3% Si have a hardness of about 285. Additions of Al, even in small proportions, improve mechanical properties; ultimate strength and hardness increase with Al content to a maximum at about 1.95% Al and then decrease again. The work of other investigators is reviewed and results given. Ha (11a)

Some Statistical Properties of an Annealed Alpha- Grain Aggregate: Part II. R. G. Johnston & W. G. Askew. *Metal Industry*, London, Vol. 45, July 13, 1934, pages 27-30. It is stated that smoothness of finished product in production of commercial non-ferrous alloys, e.g. brass strip for pressing and spinning, is greatly influenced by the character of the grain pattern. Methods to determine the grain pattern and measure grain size are discussed. The defects of the use of the arithmetical mean are indicated. A series of curves is shown based on the max. dia. and frequency as ordinates. While the fields represented by these charts were dissimilar in structure, this is not clearly shown in the plotted results. When areas and frequency were used as ordinates, relatively similar curves were obtained. Authors believed that examination of these might contribute some useful suggestions for the rational foundation of grain-size specifications. It was found that the larger the extreme sizes of grains, the greater is the irregularity of the structure. It was also noted that the ratio of the largest max. dia. to the arithmetical mean was near 2.5 in value. The authors felt this to be a genuine relationship characteristic of the grain distribution. HBG (11a)

Calcium: Its Metallurgy and Technology. C. L. Mantell & Charles Hardy. *Chemical Industries*, Vol. 35, Nov. 1934, pages 403-406. 44 references. A resume of published work. Properties tabulated. RAW (11a)

11b. Ferrous

E. S. DAVENPORT, SECTION EDITOR

Molybdenum Displaces Tungsten in New High-Speed Steel. *Iron Age*, Vol. 135, Jan. 31, 1935, page 43. Describes a Mo high-speed steel known to the trade by the name of Mo-Max steel. This type of steel was developed by Joseph V. Emmons of the Cleveland Twist Drill Co. The approximate composition of this steel is: Mo 8%; W 2%; Cr 4%; and V 1%. It is claimed to be of such high quality that it is challenging the supremacy of 18% W high-speed steel. The technique of working is similar to that which has been developed for the 18-4-1 type. VSP (11b)

Vanadium Steels (Die Vanadinstähle). HANS HOUGARDY. *Chemiker-Zeitung*, Vol. 58, Dec. 28, 1934, pages 1037-1039. In plain C steel V acts as a strong deoxidizing agent, suppresses the allotropic changes, produces smaller grain size, better physical properties, uniform physical properties in large sections, and reduces aging. It is used in the nitriding steels together with Cr and Ni in amounts of from .1 to .6% V. Up to 5% V is used in tool and high speed steel to reduce brittleness and increase hardening depth. In 18-8 stainless steel 1-1.5% V is used to prevent intergranular corrosion. CEM (11b)

Influence of Impurities on the Impact Resistance of Technical Iron (Einfluss der im technischen Eisen enthaltenen Verunreinigungen auf die Kerbzähigkeit). G. SCHMIDT. *Archiv für das Eisenhüttenwesen*, Vol. 8, Dec. 1934, pages 263-267. By remelting Armco iron under slags in a high frequency vacuum furnace, very pure Fe with controlled amounts of C, P, S, O, and N was prepared in order to study the effect of these impurities on impact resistance. In the normalized condition the impurities present tended to raise the temperature at which the sharp drop in impact resistance occurs on the impact vs. temperature curve; the maximum impact resistance was also lowered. In this respect N had the strongest effect, with P and C next in order; the effect of S was negligible. The further decrease in impact resistance and the accompanying shifting of the impact resistance-temperature curve to higher temperatures due to cold working, was also determined. The percentage decrease in impact produced by cold working was naturally greater in the material which had the higher values originally. Thus it appeared that the presence of O and S had the strongest effect in lowering the impact resistance due to cold working. (Abstractor's note. This would not seem fully to justify the conclusion that "strain" or "mechanical" aging may be attributed mainly to the presence of O and S.) SE (11b)

Some Characteristics Common to Carbon and Alloy Steels. EDGAR C. BAIN. *Yearbook American Iron & Steel Institute*, 1934, pages 86-119; discussion 119-128. See *Metals & Alloys*, Vol. 6, Jan. 1935, page MA 35. VVK (11b)

Engineering Properties of Cast Iron. E. A. PIPER. *Iron Age*, Vol. 134, Oct. 18, 1934, pages 23-29. Discusses the engineering properties of cast Fe of today, putting special stress on fundamental properties such as tensile, compression, transverse and fatigue strength. Defines cast Fe as covering a series of Fe-Si-C alloys, which also contain Mn, P and S. The term applies to gray Fe as well as to white and chilled Fe. By proper manipulation of principal constituents of cast Fe a wide range of physical, electrical and chemical properties can be obtained. Author claims that due to rapid development of gray Fe metallurgy present information in handbooks and other literature has been lagging considerably. Study of physical properties of cast Fe reveals that it is a reliable engineering material. Cast Fe has replaced many expensive alloys, due to outcome of service tests which showed more favorable results. One of the factors which has discredited cast Fe is the demand for a cast Fe permitting high rates of machining speed. Casting having ready machinability will not give high strength. Certain alloy additions as well as proper control of S and P will aid machinability. VSP (11b)

Alloys in the Ferrous Foundry. GOTTFRID OLSON. *Iron Age*, Vol. 134, Oct. 18, 1934, pages 30-34; Oct. 25, 1934, pages 29-35. Gives a brief history of alloys and defines steel, cast Fe, malleable cast Fe, and alloy steels and cast Fe. C, Si, Mn, P and S are not considered alloys as they commonly occur in cast Fe. Cast Fe derives its characteristics from these elements. Effects of Ni may be summarized as follows: (1) Added machinability and strength; (2) Decreased grain size; (3) Added resistance to wear and also to heat; (6) Added resistance to corrosion; and (7) Increased hardness. Gives analyses of a number of irons suitable for various purposes. In second instalment considers the action of Cr, Mo and W additions to foundry melts. Cr is usually used in a straight Cr-Fe mix or in combination with other alloys. Cr is carbide forming even in small % and thereby increases hardness. Care must be exercised in using Cr to give greater strength to cast Fe with good control, particularly the C, up to 0.50% Cr may be used to give added transverse and tensile strength. Mo increases tensile strength 20 to 40%; transverse strength 25 to 40%; fatigue strength about 25%; increases Brinell hardness 10 to 50 no., but improves machinability for some hardness no.; and increases resistance to abrasion and wear. W Fe withstands cutting. An Fe containing from 1-3% Cr, about 2% Cu and from ¼-1% W gives a very close Fe and one that will withstand action of cutting or eating out of Fe. Best method of adding W is to use butts of W tools. VSP (11b)

Magnetic Materials. A Survey in Relation to Structure. W. C. ELLIS & EARLE E. SCHUMACHER. *Metals & Alloys*, Vol. 5, Dec. 1934, pages 269-276; Vol. 6, Jan. 1935, pages 26-29. 27 references. Classifies magnetic materials as "soft" which have high maximum permeability, low coercive force and small hysteresis loop area and as "hard" those having low permeability, high coercive force and large area of loop. The elimination of certain elements decreases the hysteresis loop producing a "soft" material, while their addition results in a broadened loop characteristic of "hard" materials. Properties of such "soft" materials as Fe, Fe-Ni, Fe-Co alloys are described. Compositions, treatments and magnetic characteristics of common permanent magnet alloys (C, low Cr, 3.5% Cr, W and 35% Co steels) are tabulated. Fe-Ni-Al (65-25-10) alloys of 130-660 oersteds coercive and 10800-7600 gauss residual, Fe-Co-Mo and Fe-Co-W alloys of 50-300 oersteds and 12,000-8500 gauss, and oxide magnets of 600 oersteds and 4000 gauss are described. WLC (11b)

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Copper Aids Grain Structure. *Foundry*, Vol. 62, Dec. 1934, pages 23, 56. Discusses the recent interest developed in the use of Cu as an alloy in production of high test cast Fe. Considers the structure of a high test cast Fe produced by Allis Chalmers Mfg. Co., Milwaukee. The analysis of the metal is: C 2.70%; Si 2.01%; S 0.087%; Mn 0.69%; Ni 0.12%; and Cu 1.15%. Solubility of Cu in cast Fe alloys is influenced by the presence of other elements in Fe, according to J. E. Hurst. For example, in presence of 12 to 15% Ni, as much as 6 to 7% Cu is dissolved readily. It is probable that the greatest value of Cu additions to cast Fe lies in their use as a diluent of Ni additions. Plain Cu alloy cast Fe is used in motor cylinders, and a 2% Cu cast Fe under mild corrosion conditions. VSP (11b)

Raw Materials and Their Relation to Bearing Life. FAYETTE LEISTER. *Iron Age*, Vol. 134, Sept. 20, 1934, page 40-41. Describes tests conducted and precautions exercised in material control to establish definitely to what extent bearing life was influenced by cleanliness of steel used. Rings and balls were made from both clean and unclean steel; heat treated and tested to destruction under heavy loads. Results showed that bearing made from unclean steel had a very inconsistent life, while bearings made from clean steel showed increase in life with much more consistent results. Investigations were conducted by the Fafnir Bearing Co. VSP (11b)

Special Steel Developed for Wear-Resisting Service. EDWIN F. CONE. *Steel*, Vol. 95, Nov. 12, 1934, pages 49, 51. Bethlehem Steel Co. has developed a low-priced C-Mn-Si abrasive resisting steel. It is both hard and tough. Tensile strength in the as-rolled condition is 115,000-130,000 lbs./in.^{2} Brinell hardness varies from 235 to 300, according to composition. Steel is available as plates and bars. Greater care must be employed in fabrication than with ordinary plate steel, but usual shop tools and equipment can be used. Describes some of the precautions to be observed in fabrication and some of the uses. Tabulates physical properties of steel after heat treatment. MS (11b)

Copper in Gray Cast Iron. C. T. EDDY. *Foundry*, Vol. 62, Feb. 1934, pages 15, 57. Early results showed that Cu acts in similar manner to Si and Ni, and decreases tendency of cast Fe to chill. Gray Fe with improved tensile and transverse strengths is obtained by assisting graphitization, changing of pearlite into sorbite and strengthening of ferrite. Cu increases C content of the eutectoid and thereby increases the amount of combined C in gray Fe without forming free cementite. This is claimed to be the cause of increased hardness of Cu-bearing gray Fe. VSP (11b)

Characteristics of Carbon and Alloy Steels. EDGAR C. BAIN. *Blast Furnace & Steel Plant*, Vol. 22, June 1934, pages 324-327; July 1934, pages 392-394; Aug. 1934, pages 456-457, 469, 477; *Heat Treating & Forging*, Vol. 20, June 1934, pages 279-284; July 1934, pages 339-343. Paper read before the American Iron & Steel Institute. See *Metals & Alloys*, Vol. 6, Jan. 1935, page MA 35. MS (11b)

Stainless Steel, Its Properties and Its Application (Rustfritt staal, dets egenskaper og dets anvendelse). TH. SMITH-CHRISTENSEN. *Teknisk Ukeblad*, Vol. 82, Jan. 3, 1935, pages 3-5 (with discussion). Paper read before Polytechnic Society of Norway, Dec. 18, 1934. Explains the passivity obtained by addition of Cr to steel and discusses the effect of other alloying constituents, such as Ni, Mo, Mn, W, Ti, Cu, Al, Co, and Si. The physical properties of Cr and Cr-Ni steels are discussed, also the effect of the C content, methods of heat treatment, welding, and resistance to high temperatures and corrosion. Many technical and commercial applications are given. Production of these steels in Norway was started in 1917; present production is at a rate of about 1,000 metric tons per year. BHS (11b)

1

Soft Cast Iron. L. W. BOLTON. *Foundry Trade Journal*, Vol. 51, Aug. 30, 1934, pages 137-138. Extracted from the *Bulletin of the British Cast Iron Research Association*. See *Metals & Alloys*, Vol. 6, Jan. 1935, page MA 34. AIK (11b)

2

The Influence of Vanadium on Carbon Steels and on Steels Containing Nickel and Chromium. H. H. ABRAM. *Engineering*, Vol. 138, Nov. 2, 1934, pages 482-484. From a communication from the Research Department, Woolwich, presented at the Brussels meeting of the Iron & Steel Institute, Sept. 1934. See *Metals & Alloys*, Vol. 5, Dec. 1934, page MA 582. LFM (11b)

The Selection of Steels for Engineering Requirements. FRANCIS W. ROWE. *Mechanical World & Engineering Record*, Vol. 96, Oct. 5, 1934, pages 322-323. **Selection of Alloy Steels.** Oct. 12, 1934, pages 344, 346. **Selection and Inspection of Steels.** Oct. 26, 1934, pages 392-394. Abstracts of paper presented to Manchester Association of Engineers. First article deals with plain and lightly alloyed C steels; second with Ni, Cr, Mo steels, case-hardening, and corrosion and heat-resisting steels. Procedure of practical selection, inspection and classification of steels on a basis of duty are discussed in the concluding article. Kz (11b)

3

Properties of Nickel-Aluminum Magnet Steel (Eigenschaften von Nickel-Aluminium-Magnetstahl). W. S. MESSKIN & E. SOMIN. *Archiv für das Eisenhüttenwesen*, Vol. 8, Jan. 1935, pages 315-318. Alloys of Fe with 25% Ni and 12.4-17.6% Al were melted in an induction furnace and the magnetic properties studied. Virtual saturation was obtained in a magnetic field of 10,000 oersted. Curves are shown of the magnetic properties as influenced by composition and heat treatment (quenching and tempering for precipitation hardening). The effect of C content on the alloys was not very marked. SE (11b)

4

A New Magnetic Material for the Cores of Pupin Coils (Een nieuw magnetisch materiaal voor de kernen van pupinspoelen). N. SIX, J. L. SUVEK & W. G. BURGERS. *De Ingenieur*, Vol. 49, Dec. 28, 1934, pages 195-200. Construction and investigation of a new magnetic material is described for loading coil cores which consists of a very thinly rolled strip of 50-50 Ni-Fe alloy rolled into an annular core; the thickness is about 60 microns. The very small hysteresis losses of this material are ascribed to magnetic anisotropy due to a pronounced orientation of the crystals as a result of recrystallization before the last rolling takes place. Tests and possible savings over other materials are described. Ha (11b)

The Elasticity, Deflection and Resilience of Cast Iron. J. G. PEARCE. *Foundry Trade Journal*, Vol. 51, Aug. 2, 1934, pages 76-80. From paper read before British Iron & Steel Institute. See *Metals & Alloys*, Vol. 5, Oct. 1934, page MA 494. AIK (11b)

6

The Physical Properties of Iron-Aluminium Alloys. C. SYKES & J. W. BAMPFYLDE. *Engineering*, Vol. 138, Nov. 23, 1934, pages 578-580. From paper read before the Iron & Steel Institute, Brussels, Sept. 11, 1934. See *Metals & Alloys*, Vol. 5, Dec. 1934, page MA 582. LFM (11b)

Periodic Hardness Fluctuations Induced in Metals by Mechanical Thermal and Magnetic Disturbances. EDWARD G. HERBERT. *Engineering*, Vol. 136, Dec. 7, 1934, pages 631-632. From a paper read before Sub-section AG of the British Association for the Advancement of Science, Sept. 1934. See "Periodic Fluctuations in Metal," *Metals & Alloys*, Vol. 6, Jan. 1935, page MA 36. LFM (11b)

7

A New Material for Permanent Magnets. *Edgar Allen News*, Vol. 13, Dec. 1934, page 571. The steel is a Ni-Al-Fe alloy of undefined composition. It cannot be forged and must be used in the cast state. The coercive force is about double and the remanence about 2/3 that of a 35% Co steel. Ha (11b)

The Improved Tensile Properties of Structural Steel. HERBERT J. DAVEY. *Inspection*, Vol. 5, Oct. 1934, pages 1-5. The steel, "Chromador," is rolled to give a tensile strength of 37-43 tons/in.^{2} with a minimum yield point of 23 tons. The chemical composition is given as follows: 0.22% C, 0.80% Mn, Si not stated, 0.90% Cr, 0.30% Cu. Kz (11b)

8

Classification of Cast Iron Samples from Bending Tests to Rupture (Keuring van Gietijzer op buiging tot breuk). IR HAMELINK. *De Gieterij*, Vol. 8, Apr. 1934, pages 47-49. A summary of the conclusions of the Standardization Commission for the Netherlands on the classification of the cast iron metals and a comparison with the conclusions of the German Commission are reviewed, interpreted for the foundry operator and summarized in a table. MPW (11b)

9

Origin of Surface Flaws of Steel Sheets. EMMY MARKE. *Iron Age*, Vol. 134, Sept. 13, 1934, pages 30-32. Abstract of a report to sub-committee for sheet metals for the Verein Deutscher Eisenhüttenleute. See "Surface of High Grade Sheet," *Metals & Alloys*, Vol. 5, July 1934, page MA 344. VSP (11b)

Effect of Arsenic and Antimony upon Cast Iron. E. PIWOWARSKY, J. VLADESCU & H. NIPPER. *Foundry Trade Journal*, Vol. 50, Apr. 19, 1934, page 259. Abstract of translation from *Archiv für das Eisenhüttenwesen*. See *Metals & Alloys*, Vol. 5, July 1934, page MA 356. CEJ (11b)

10

Influence of Rolling on Mild Sheets. C. A. EDWARDS. *Blast Furnace & Steel Plant*, Vol. 22, May 1934, page 292. See *Metals & Alloys*, Vol. 5, May 1934, page MA 225. MS (11b)

Contributions to the Knowledge of Chilled Cast Iron (Beiträge zur Kenntnis des Schalenhartgusses). FRANZ POHL. *Giesserei*, Vol. 22, Jan. 18, 1935, pages 27-31. The characteristic properties of chilled castings, surface hardness and depth of chill, were investigated with regard to dependence on chemical and thermal influences. The cementite in cast Fe increases with increasing C content and increasing hardness. The depth of chill shows a decrease of 5 mm. for each 0.1% increase of C for the same content of Si; previous views that the depth depends solely on the Si content are not correct. This depth increases, however, with decreasing content of graphite in the original material. The casting solidifies in the carbide system more readily the higher the heating temperature. The depth increases with increasing duration of heating (at same temperature); higher temperature produces finer graphite. In the chilled cast iron system (pearlite + carbide) no essential increase in hardness is effected by addition of Si. An increasing amount of Si reduces the depth of chill in high C chilled iron. Mn does not increase surface hardness appreciably in the range of 0.3-1.5% Mn. From 0.40-0.6% Mn the depth of chill is reduced to a minimum and then increases again. This is explained by the interaction of Mn, S and Fe. The ratio of Mn to S determines the depth of chill. Increasing P content increases surface hardness due to formation of an iron phosphide eutectic. Depth of chill decreases considerably with increasing P content; for the same C and Si content it decreases about 2 mm. for each 0.1% P increase; the effect is about half that of Si and C. Cooling conditions have a great effect on the fineness of grain, the hotter the pouring temperature the greater the surface hardness and fineness of grain. The time of contact between ingot and chill mold changes the quenching effect; the depth of chill is increased with increasing time independent of chemical composition and pouring temperatures. 5 references. Ha (11b)

Notes on Cylinder Castings for Air-cooled Motors, with Particular Reference to Additions of Copper (Betrachtungen über Zylinderguss für luftgekühlte Motoren, unter besonderer Berücksichtigung eines Kupferzusatzes). H. KOPP. *Mitteilungen aus den Forschungsanstalten des GHH-Konzerns*, Vol. 3, Feb. 1935, pages 192-198. Cylinder castings are made of 3 kinds of Fe: (1) high grade cast Fe, unalloyed, (2) high grade gray Fe with a little Cr and Ni, without heat-treatment, (3) high grade gray Fe with Cr and more Ni, generally heat-treated. Heat conductivity is usually not greatly affected by the additions. Experiments with Cu additions were made and compared with results of other investigators. Cu reduced the heat conductivity somewhat (2.36% Cu reduced it to 93% of the unalloyed material) but this was compensated for by an increased and coarser graphite separation which tends to increase heat conductivity. Greater effect was shown in Brinell hardness which increased from 210 to 245 as the Cu varied from 0 to 2.5%. The wear resistance, however, decreased noticeably with increased Cu addition; the behavior of Cu is, in this respect, similar to Ni. The experiments do not give conclusive evidence in favor of, or against, Cu addition. 8 references. Ha (11b)

Grain Size vs. Surface Hardness; A Question of Mass. E. S. DAVENPORT with reply from R. L. WILSON. *Metal Progress*, Vol. 27, Jan. 1935, pages 44-45. Davenport cites work of Bain and Grossmann supporting the thesis that coarse grain, deep hardening steels show lower intensity of surface hardness than fine grain shallow hardening steels in various hardenability investigations. Wilson in reply brings out that, while the drastic quenches of hardenability tests retain considerable austenite on surface of deep hardening steels resulting in lower hardness, in the quenching of actual production items of larger sizes scale conditions and mass cause less rapid quench which fails to retain austenite and under these conditions coarse grained steels show higher surface hardness than fine grained ones. WLC (11b)

Recent Developments in Cast Iron. WALTER WEST. *Metallurgia*, Vol. 11, Dec. 1934, pages 54-56. Ni, Cr, Ni-Cr, Mo, Mo-Cr, and Ni-Mo gray irons are discussed. Mechanical properties of Mo, Cr-Mo, and Ni-Mo irons given in the article show that strength increases as Mo is added in amounts up to 1%. Cast iron crank shafts are mentioned. Their development is under way in England. JLG (11b)

Travel of a Pulse of Stress in a Steel Wire. T. F. WALL. *Nature*, Vol. 133, Mar. 17, 1934, page 419. Velocity of a pulse of stress in ¼" diam. bright drawn steel wire, 495 ft. long, was measured by solenoid and oscillograph, giving velocity = 5.04×10^5 cms./sec., E = 29×10^6 lbs./in.^{2} Internal damping, measured simultaneously, affords possible means of detecting work hardening in the wires of wire ropes. CSB (11b)

Abnormal Permeability Produced in a Steel Wire by Loading. T. F. WALL. *Nature*, Vol. 133, June 23, 1934, page 949. An annealed mild steel wire that had not been subjected to fatigue was found to increase its permeability by a factor of 10 for low values of H when subjected to a steady load of 13.7 tons/in.^{2} CSB (11b)

Effects of McQuaid-Ehn Grain-Size on the Structure and Properties of Steel. PHILIP SCHANE, JR. *Transactions American Society for Metals*, Vol. 22, Dec. 1934, pages 1038-1050. Paper read at Grain-Size Symposium, A.S.M. Convention, 1934. Discusses grain-size control in S.A.E. 1040 forging steels. Data show wide variation in impact values on forgings with variation in grain-size. Mixed grain-size is to be avoided and a uniform structure obtained before heat treatment if good physical properties are to be obtained. Author states that these conditions are best met by control of grain-size in steel manufacture. WLC (11b)

Standardized Tool Steels. B. M. SUSLOV. *Metal Progress*, Vol. 27, Jan. 1935, pages 46-47. Soviet state control of tool steel manufacture has made possible standardization of such steels into much fewer grades than in other countries. Availability of Mn, Si, Cr and V in Soviet Union have been taken into account in analysis specifications with W and Mo used to minimum extent on account of lack of these ores in Russia. WLC (11b)

The Influence of the Overvoltage of Cathodic Hydrogen on the Tensile Strength of Various Steel Materials (Einfluss der Überspannung des Kathodischen Wasserstoffes auf die Festigkeit Verschiedenen Stahlsorten). TIBOR KRASSO. *Zeitschrift für Elektrochemie*, Vol. 40, Dec. 1934, pages 826-829. The absorption of H, cathodically produced, by steels is a function of the overvoltage. The addition of As to H_2SO_4 or Hg to NaOH electrolytes increases H absorption as do the addition of Ni or Cr to steel. Percentage of original tensile strength at which tearing occurs after H absorption is given in table. WB (11b)

The Age-Hardening Characteristics of Some Copper-Nickel-Silicon Alloys. Bruce W. Gonser & L. R. van Wert. *Metals & Alloys*, Vol. 5, Nov. 1934, pages 251-255; Dec. 1934, 281-283. 9 references. Reports a study of solution treatment, quenching conditions, age-hardening, effect of cold work, electrical conductivity, dilatometric, metallographic and X-ray examination of three alloys of following compositions,

	Cu	Ni	Si	Al	Ni_2Si (calc.)
A	89.29%	4.42%	0.98%	5.31%	5.07%
B	96.81	2.43	0.57	nil	2.95
C	97.78	1.77	0.40	nil	2.08

WLC (11b)

Position of Cast Iron in the Strength Scale (La Position de la Fonte dans l'Échelle des Résistances). Gustav Meyersberg. *Bulletin de l'Association Technique de Fonderie*, Vol. 8, Aug. 1934, pages 396-402. Paper presented at the Nancy Foundry Congress, July 1934. Cast iron, although not as strong as some other materials, has certain advantages, such as wear resistance, high damping capacity, cheapness, and lack of sensitivity to external defects. 10 references. WHS (11b)

Copper as an Alloying Element in Steel. H. L. Miller. *Metals & Alloys*, Vol. 5, Oct. 1934, pages 227-228. Cu is most effective as a cheap alloying addition to strengthen ferrite and give more uniform physical properties. A steel of 0.30% C, 0.70% Mn, 1.40% Cu, 0.25% Mo gives yield points in normalized sheets 1/16" to 1/4" gage that vary less than 5000 lbs./in.² compared to variation of 20,000 lbs./in.² in yield point in similar gage sheets of C-Mn steel. Atmospheric corrosion resistance is increased by Cu additions. WLC (11b)

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Low Alloy, High-Tensile Steels. Edwin F. Cone. *Steel*, Vol. 95, Sept. 24, 1934, pages 41-44, 66. Reviews composition and physical properties and some of the claims made for low-Ni, medium-Mn, high-tensile Si, 1.25-1.75% Cu, "Cromansil," Cr-V, C-V, Mn-V, Mn-Mo, high Si + Mo, C-Mo, "Cor-Ten," "Man-Ten," and "Sil-Ten" steels. These materials offer economies in reducing
1 weight without sacrificing strength. MS (11b)

Standardized Aluminum Alloys (Genormte Allminium-Legierungen). *Technische Blätter der deutschen Bergwerkszeitung*, Vol. 24, Dec. 2, 1934, page 674. Discusses the draft of proposed German standards, October 1934, for malleable and
— cast Al alloys. Proposed by Deutsche Gesellschaft für Metallkunde in coöperation with producers and consumers. GN (11b)

The P-F Characteristic of Steel. B. F. Shepherd. *Transactions American Society for Metals*, Vol. 22, Dec. 1934, pages 979-1016. Paper read and
2 discussed at Grain-Size Symposium, A.S.M. Convention 1934, previously abstracted from Preprint 31, 1934, see *Metals & Alloys*, Vol. 5, Nov. 1934, page MA 517. WLC (11b)

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Influence of Manganese on Hardening Ability of Carbon Steels. Werner Jellinghaus. *Iron Age*, Vol. 134, Sept. 6, 1934, pages 20-25. See *Metals & Alloys*, Vol. 5, Jan. 1934, page MA 30. VSP (11b)

Effect of Beryllium on Steel (Der Einfluss von Beryllium auf Stahl). W. Kroll. *Zeitschrift Verein deutscher Ingenieure*, Vol. 79, Jan. 5, 1935, pages 28-
3 29. Properties of Be, present knowledge of Be-steels and practical applications are reviewed. 11 references. Ha (11b)

12. EFFECT OF TEMPERATURE ON METALS AND ALLOYS

L. JORDAN, SECTION EDITOR

The abstracts in this section are prepared in co-operation with the Joint High Temperature Committee of the A.S.M.E. and the A.S.T.M.

Aging Embrittlement of 4 to 6 per cent Chromium Steel. H. M. Wilten & E. S. Dixon. *Proceedings American Society for Testing Materials*, Vol. 34, Pt. II, pages 59-78, discussion page 79. Low-C 4-6% Cr steel is being extensively used in the oil refineries in the form of heater tubes. Such tubes are, at times, subject to embrittlement after exposure to operating temperature (approx. 900° F.). While being cleaned of coke deposit a small percentage of tubes crack, due to shock stresses on embrittled tubes. An investigation of the physical properties of new and failed tubes led to the following conclusions. The normal failure of 4-6% Cr steel in refinery use is usually accompanied by creep, resulting in considerable visible swelling. Abnormal failures result from shock stresses applied to embrittled metal. Embrittlement of 4-6% Cr steel can usually be brought about by simple prolonged exposure of most heats of this steel to a temperature of 900° F. Most heats of 4-6% Cr steel show high degree of susceptibility to temper brittleness. From a theoretical point of view the authors conclude the following. The embrittlement of 4-6% Cr steels is accompanied by no, or at most, a negligible, increase in hardness or tensile strength. Embrittlement is revealed by the drop in impact value. This type of embrittlement can be brought about by long exposure to temperatures in the neighborhood of 900° F. regardless of the rate of cooling. In some instances, correlation has been found between this type of embrittlement and temper brittleness. The embrittlement of 4-6% Cr steel may be due to aging as a result of structural alteration of solid solution, the same as occurs in the aging of duralumin at ordinary temperatures. The evidence that it is not due to a precipitation of some constituent is shown by the improvement in impact value of these steels when broken at 212° F., the absence of hardening, non-aging susceptibility after quenching from near the A_1 point, and, finally, the absence of intercrystalline corrosion in abnormally failed tubes. Temper brittleness of various steels in general may also result from the same type of aging. 13 references. VVK (12)

Creep Properties of 5 per cent Chromium, 0.50 per cent Molybdenum Steel Still Tubes. H. C. Cross & E. R. Johnson. *Proceedings American Society for Testing Materials*, Vol. 34, Pt. II, 1934, pages 80-100, discussion pages 101-104. Creep properties of the 5% Cr, 0.50% Mo type of steels with 0.139 and 0.181% C were determined. Specimens were cut from finished still tubes to represent both longitudinal and transverse directions. Five heat treatments, representing normalizing and slow cooling from 1550° F. and 2100° F. were used to produce different structures and grain sizes. Hardness, impact resistance, susceptibility to temper brittleness, and short-time tensile properties at room temperature, 1000°, 1100° and 1200° F. were determined. Creep properties at 1100° F. for specimens slowly cooled from 1550° F. and the relative creep properties at one stress at this temperature for the four other heat treatments were determined for steels of both carbon contents. A few creep data at 1200° F. are also included. Increase in C content from 0.139 to 0.181% materially increased the physical properties and creep resistance. Longitudinal material showed better creep resistance than transverse material of either C content, but the differences were less than 10%. Better creep properties were obtained for slowly cooled specimens than for normalized specimens. Uniform structures with well-defined grain were obtained by slow cooling, but normalized and reheated materials of comparable hardness showed less uniform structures. Impact resistance of transverse material was lower than for longitudinal material. Impact tests made on specimens subjected to load and temperature for 1000 hr. or more revealed no notable drop in toughness. After the specimens had been subjected to creep tests, the hardness, impact resistance, and short-time tensile properties were determined. It is concluded that subjecting these steels to creep testing at 1100° and 1200° F. has little effect on the hardness, impact resistance, or tensile properties in short-time tests, thus indicating that these steels are quite stable at 1100° and 1200° F. VVK (12)

Interpreting Creep Tests for Use of Metals at High Temperatures. P. G. McVetty. *Iron Age*, Vol. 134, July 26, 1934, pages 16-19. See *Metals & Alloys*, Vol. 6, Jan. 1935, page MA 36. VSP (12)

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Tensile Properties of Materials at Low Temperatures (Die Festigkeitseigenschaften der Werkstoffe bei tiefen Temperaturen). W. Schwinning. *Zeitschrift Verein deutscher Ingenieure*, Vol. 79, Jan. 12, 1935, pages 35-40. Review of the effects of low temperatures on notch-toughness and endurance strength
5 of C steels, alloy steels and non-ferrous metals. Tensile strength, elastic limit and alternating bending strength of steel increase considerably at lower temperatures (down to —40° C.). The alternating bending strength of steels, for both smooth and notched bars, showed almost twice as great an increase at the low temperature as did the tensile strength. Cu showed a similar behavior except for the elastic limit of very soft annealed Cu. The change in properties of light
— metals is almost negligible for temperatures down to —40°. Structures of steel have, therefore, a higher margin of safety at low temperatures than at room temperatures. Brittleness in C steels increased at low temperatures more if the material was previously cold-worked and stored for a time at room temperature. Cold-brittleness is dangerous even for slight reduction in temperature if strong
6 notch effects are present; the dangerous effects shift toward colder temperatures with reducing notch effects. Ha (12)

Remarks on the Paper: Cast Irons Resistant to High Temperatures (Notes relatives au Bulletin sur: Les Fontes résistant aux Températures élevées) by Dawans and Denoel. *Revue Universelle des Mines*, Vol. 11, Feb. 1, 1935,
— pages 68-70. A discussion by Portevin and Kinzel & Moore of the paper in *Revue Universelle* of Nov. 1, 1934, in which the authors' statement that a theoretically lower limit exists for the reversibility below which no further graphitization takes place, is contradicted and proof is adduced that this limit
7 depends on time and velocity of heating; 250° C./hr. was determined dilatometrically as temperature of the beginning of graphitization. Also in weakly carburized steels graphitization can take place; in fact, at a temperature below the eutectoid temperature the only stable phase of the system Fe-C is the graphite. Ha (12)

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An Automatic Creep Test Furnace. P. H. Clark & E. L. Robinson. Discussion by Francis B. Foley. *Metals & Alloys*, Vol. 6, Feb. 1935, pages 46-51. Describes furnace and controls of installation for running 12 creep test specimens of 20" gage length simultaneously. Discussion describes individual
8 specimen furnaces for testing 2" gage length specimens and routine of recording data. Data reported indicate that very long time tests may markedly change our ideas of creep strength of a given material. WLC (12)

Effect of Temperature on the Properties of Metals, Report of Joint Research
— **Committee.** *Proceedings American Society for Testing Materials*, Vol. 34, Pt. I, 1934, pages 207-212. **Proposed Revisions in Tentative Methods for High-Temperature Tension Tests of Metallic Materials.** *Appendix*, pages 213-216. Progress report. VVK (12)

Factors Influencing Creep of Steels at Elevated Temperatures. A. E. White,
9 C. L. Clark & R. L. Wilson. *Steel*, Vol. 95, Dec. 10, 1934, pages 30-34. See "Qualifications of Steels for High Temperature Service in Petroleum Refinery Equipment," *Metals & Alloys*, Vol. 6, Jan. 1935, page MA 36. MS (12)

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Compression Tests of Structural Steel at Elevated Temperatures. Prentiss D. Sale. *Bureau of Standards Journal of Research*, Vol. 13, Nov. 1934, pages 713-743. **Strength of Structural Steel at Elevated Temperatures.** *Mechanical World & Engineering Record*, Vol. 97, Jan. 18, 1935, pages 61-62, 67. The strength in compression and the stress-strain relations are given for structural-
10 steel shapes and for round bars at temperatures up to 945° C. One group of tests of cast-Fe specimens is included for purposes of comparison. Two general methods of testing are included, one in which the specimen is heated to a given temperature and loaded to failure, and the other in which the load is maintained constant and the temperature increased until failure occurs. WAT + Kz (12)

13. CORROSION AND WEAR

V. V. KENDALL, SECTION EDITOR

Pipe-Line Protection. ARTHUR B. ALLYNE. *Gas Age Record*, Vol. 74, Oct. 20, 1934, pages 335-336. Committee report presented before the Pacific Coast Gas Association, Del Monte, Calif. Oct. 1934. A steel pipe line can be protected from soil corrosion by continuously maintaining the pipe at a negative potential with respect to the surrounding soil. It was observed that when the electrical drainage was interrupted the pipe did not immediately return to ground potential which suggested the possibility of intermittent drainage. Laboratory tests, which data are shown in curves, based on loss in weight, showed that the intermittently drained samples were afforded practically the same protection as those that were continuously drained and at one-third the power cost. These results also appear to substantiate the assumption that steel is protected from soil corrosion whenever it is at all negative to the surrounding soil. VVK (13)

Value of Stainless Steels in Chemical Industry (Der Wert der nichtrostender Stähle in der chemischen Industrie). F. WINTER. *Die Metallbörse*, Vol. 24 May 26, 1934, pages 661-662; May 30, 1934, pages 679-680. Discusses ferritic, martensitic and austenitic stainless steels and the transitions between these groups. The following classification according to chemical analysis is made: ferritic steels: 0.2-0.4 C, 25-32 Cr; ferritic-carbidic steels: 0.4-2.0 C, 25-32 Cr, 2.0 Mo; semi-ferritic steels: 0.4-2.0 C, 13-18 Cr, Ni max.; martensitic steels: (1) 0.15-0.25 C, 13-15 Cr, 0.5-2.0 Ni. (2) 0.35-0.45 C, 13-15 Cr .5-2.0 Ni, 2 Mo max. Austenitic steels: (1) 0.4 C, 18-22 Cr, 7-10 Ni, 3 Mo max. (2) 0.1-0.4 C, 18-26 Cr, 15-80 Ni. The oxide film theory suggested by Haber & Goldschmidt is now generally accepted and optically confirmed. The film thickness is less than 10 A.U. Chemical reagents promoting oxidation, for instance boiling HNO_3 up to 60% do not corrode stainless steels. H_2O_2 and other oxidizing agents stop corrosion of acids, for instance HCl. H liberating acids (HCl) cause uniform surface attacks, salts promote pitting. Inclusions such as sulphides and silicates are not a source of localized corrosion as is mill scale. HNO_3 pickling and annealing at 200°C. in air furnish a protective oxide film. High surface polish counteracts corrosion due to the formation of more uniform and tightly adhering films. Decreased corrosion stability in H_2SO_4 is ascribed to cold working during improper grinding and polishing. Cold rolling impairs the stability of the oxide film. 18/8 ranges above Ag in the electromotive series whereas Ni, Monel metal and Cr showed higher potentials in electro-chemical tests. Cr raises, C lowers the corrosion resistance of 18/8 to boiling acetic acid, phosphoric acids of various concentrations and sulphurous acid at higher pressures and elevated temperatures. Commercial utilizations of stainless steel in chemical industry are given. EF (13)

Valve Seat Wear. C. G. WILLIAMS. *Automobile Engineer*, Vol. 25, Jan. 1935, pages 23-24. A report of the (British) Research and Standardization Committee of the Institute of Automobile Engineers describes results of experiments with various insert materials in valves; the wear is expressed as wear in inches for 50 hrs. working. The wear was below 10/1000" for stellited seat with stellited valve. Monel metal seat with KE965 valve, Ni coated seat, stellited seat, Ni-Be seat, all with KE 695 valve, in the order named, the last having about 4/1000" wear; then comes a 32% Cr-Fe seat with 0.8, Al bronze seat with 25, austenitic cast Fe seat with 29, cast Fe "B" seat with 30, Cu-Zn alloy seat with 34, cast Fe "A" seat with 48/1000" wear, again all with KE 695 valve, and last cast Fe "A" seat with stellited valve with 70/1000" wear. Composition of the various metals used for the seats is given and results in detail shown in curves. Ha (13)

Rebuilding Pulp Grinder Shafts—Application of Wear-Resisting Bronze Eliminates Troublesome Effects of Corrosion. HARRY A. WALKER & D. S. LLOYD *American Welding Society Journal*, Vol. 14, Jan. 1935, pages 9-10. Dilute acid products of wood responsible for worn threads of grinder. Taken out of service, undercut for laying bronze weld and thread recut. Special bronze rod for oxyacetylene welding contains deoxidant. WB (13)

Corrosion Phenomena. 18th Communication. Localization of the Inhibiting Action of Surface-Active Matter During the Solution of Metals in Acids (Über Korrosionserscheinungen. 18. Mitteilung. Die Lokalisation der hemmenden Wirkung oberflächenaktiver Stoffe bei der Auflösung von Metallen in Säuren). A. THIEL & C. KAYSER. *Zeitschrift für physikalische Chemie*, Abt. A, Vol. 170, Nov. 1934, pages 407-420. The object of these experiments with "subdivided local elements" (dissolving of metals separated from gas evolution) was to decide whether the action of the inhibitors during the solution of metals in acids, occurs at the active spots where the metal goes into solution or in the centers of gas liberation localized at the nobler contaminations. Cells of Cd-Pt, Cd-Cu, Zn-Pt, (Fe-Pt) were studied in relationship to additions of gum arabic, gelatine, methyl-violet. Contrary to previous determinations of Schunkert (See *Metals & Alloys*, Vol. 5, Aug. 1934, page MA 422 L-4) it was found that the adsorption of foreign matter essentially affects only the gas development at the surface of metals, whereas the actual solution process of the metals is affected to a lesser extent. EF (13)

Tarnishing of Silver and Its Prevention (Das Anlaufen des Silbers und seine Verhütung). E. RAUB. *Mitteilungen des Forschungsinstituts und Probieramts für Edelmetalle*, Vol. 8, Sept. 1934, pages 61-67; Oct.-Nov. 1934, pages 77-84; Jan.-Feb. 1935, pages 105-112. The various forms of corrosion and rapid tests to determine tarnishing resistance of Ag are described. The conclusion is that at present no Ag alloy yet exists which is practically tarnish proof, and the chances that such an alloy may be found are not very promising. For this reason, the surface of Ag articles is at present made resistant to tarnishing S compounds by coating. Of the many methods proposed, 3 have found practical application: (1) coating with a transparent lacquer (zaponize), (2) plating with tarnish-proof metal (Cr, Rh), (3) passivation by forming a covering layer (Finckh process). The latter, DRP 572 324, (not fully described) uses the chromic acid anion for producing a film which, in addition to being tarnish-resisting, has also a fairly good mechanical resistance. Ha (13)

Factors in Soil Corrosion of Ferrous Metals. A Discussion of Electrolysis and Pitting. *Gas Engineer*, Vol. 11, Oct. 1934, pages 521-523. A study of electrolysis and pitting in soil corrosion is made based mainly on the test results of E. R. Sherman (*Industrial & Engineering Chemistry*, Vol. 26, No. 7). WH (13)

Corrosion of Copper Steels (Zur Korrosion der Gekupferten Stähle). G. TAMMANN & K. L. DREYER. *Zeitschrift für anorganische und allgemeine Chemie*, Vol. 221, Dec. 28, 1934, pages 124-128. Corrosion resistance of Cu steels depends upon formation of adherent Cu film which is the case when exposed to pure water or acid solutions (H_2SO_4 and HCl). When the acid contains an oxidizer or is aerated or if exposure is in salt solutions (NaCl or sea water) non-adherent, spongy Cu deposit forms which is non-protective. In the corrosion of Cu steels no Cu ions are found in solution but appear to spread over the Fe surface. A protective film of Cu $1x10^{-6}$ mm. thick is sufficient to give the steel the Cu potential, this is 3 atoms deep and does not show Cu color. Tests were made with electrolytic Fe and Fe with .25%, .5% and 1.0% Cu. These were rolled into sheet. Microscope showed solubility of .4% Cu at 600° C. The evaluation of corrosion was made on the basis of a definite volume of H gas evolved for a definite time. Addition of Na_2S to acid solutions increased corrosion of Cu steels 7 times, still this was under the corrosion figure for electrolytic Fe. Inorganic or organic material of porous nature (wood, cork, clay, etc.) when clamped to the Cu steel sheets, localized and tremendously increased corrosion under the material. WB (13)

The Rust Racket and Its Nemesis. C. C. SNYDER. *Iron Age*, Vol. 134, Aug. 2, 1934, pages 26-29, 80. Deals with the part played by stainless steel and Fe in combating corrosion. Major industries vitally concerned with corrosion are the meat packing, chemical, dairy, and brewing industries, etc. Considers the advantages of using stainless steel and Fe by these industries. Various government agencies are giving these stainless metals serious consideration. VSP (13)

Topo-Chemical Phenomena in Metallurgy (Topochemische Vorgänge in der Werkstoffkunde). HANS STÄGER. *Kolloid Zeitschrift*, Vol. 68, Aug. 1934, pages 137-146. The traditional characterization of metallic materials by determination of their physical properties is more and more supplemented by further tests set up under physico-chemical, colloidal-chemical and topo-chemical viewpoints. The growth of cast Fe, formation of Fry's flow lines, corrosion of metals and alloys (18/8 disintegration, attack of S-bearing combustion gases on Ni and 19 Ni-17 Cr steels, dezincification of brass) and corrosion fatigue are discussed at great length under topo-chemical viewpoints which are supoprted by 16 microstructures. EF (13)

Origin of Wear Oxidation (Beitrag zur Entstehung der Reiboxydation). F. ROLL & W. PULEWKA. *Zeitschrift für anorganische und allgemeine Chemie*, Vol. 221, Dec. 28, 1934, pages 177-181. The effect of load, velocity of rubbing and temperature of rubbed surfaces on the production of Fe_2O_3 or Fe_3O_4 was determined. The velocity of the oxidation reaction and the amount of product shown to be a function of the temperature of the rubbed surfaces. With low hardness of surfaces (120 Brinell) the wear oxidation is low and forms Fe_2O_3 but with high Brinell (500) Fe_3O_4 forms. WB (13)

Protection of Ferrous Materials by Direct Electrolytic Deposits of Zinc and Cadmium (La protezione di materiali ferrosi a mezzo di depositi elettrolitici immediati di zinco e di cadmio). F. PIETRAFESA. *La Metallurgia Italiana*, Vol. 26, Dec. 1934, pages 937-948. The resistance of Zn-plated and Cd-plated Fe to the action of a spray of 20% salt solution has been determined. Both protect Fe, but Cd gives the greater protection, as its corrosion product tends to prevent further corrosive action. The rate of corrosion of Zn-plated material varies directly with time of exposure, while the rate for Cd-plating is proportional to the cube-root of the time of exposure. The minimum film of plating required to withstand the action of the salt spray for 60 days is 0.0075 mm. for Cd, and 0.015 mm. for Zn. Cd is best plated from an alkaline bath, Zn from an acid bath. 31 references. AWC (13)

Corrosion Tests of Mild Steel Sheets. F. EISENKOLB. *Iron Age*, Vol. 134, Sept. 20, 1934, page 41. Abstract translation of an article published in July 1934 issue of *Korrosion und Metallschutz*. See "Atmospheric Tests of Thin Sheets of Soft Steel," *Metals & Alloys*, Vol. 6, Jan. 1935, page MA 39. VSP (13)

Observations on Effect of Surface Finish on the Initial Corrosion of Steel Under Water. L. J. WALDRON & E. C. GROESBECK. *Proceedings American Society for Testing Materials*, Vol. 34, Pt. II, 1934, pages 123-131; discussion pages 132-137. The investigation was undertaken to determine what effect different surface finishes may have on the results obtained in the initial stages of any corrosion test. The points studied were: (a) the effect of variations in the surface finish on the loss in weight of specimens with and without an oxide film at low and high velocities of flow; (b) the time of exposure to the air during which an oxide film forms on coarsely ground specimens prior to test; and (c) the relation between duration of immersion (up to 28 days) at various velocities of flow and the loss in weight of specimens with or without an oxide film. The water used was Washington city water of pH 7.6-7.8 saturated with air. Results indicate that, in general, the presence of an oxide film on the specimens does not have any marked influence on the corrosion losses at low velocities of flow, but that it does at relatively high velocities. The character of the oxide film is dependent upon the surface finish of the metal, the atmosphere to which the specimen is subjected prior to immersion and duration of exposure to that atmosphere. Using distilled water instead of tap water, it was indicated that oxide films formed in dry air in a desiccator, previous to immersion in the water, have a far less important effect in distilled water than in tap water, even at a velocity of 225 ft. per min. VVK (13)

The Determination of Traces of Dissolved Oxygen by the Winkler Method. M. C. Schwartz & W. B. Gurney. *Proceedings American Society for Testing Materials*, Vol. 34, Pt. II, 1934, pages 796-812; discussion pages 813-820. The conventional Winkler method for determining dissolved oxygen has been compared with a modified bi-iodate method at very small concentrations of oxygen. The use of the bi-iodate method has been shown in (1) eliminating the assumption of a constant sensitivity by automatically cancelling the sensitivity correction as an element of the determination; (2) obtaining agreement, and practically true determination, on the oxygen value of a sample notwithstanding the use of Winkler reagents of differing degrees of contamination which by the standard procedure would give results considerably at variance. Procedures are suggested for determining the true oxygen content of samples in the neighborhood of zero oxygen. 112 references. VVK (13)

Paint Coatings on Moist Material (Über Anstriche auf feuchtem Untergrund). Hans Wolff & Gerhard Zeidler. *Farben Zeitung*, Vol. 39, Oct. 20, 1934, pages 1070-1072. It is generally assumed that paint coatings should not be applied to moist material. The authors point out that there is a decisive difference in the effect of superficially adhering moisture (as for instance dew) and H_2O present in the "pores of Fe." The former becomes emulsified due to the mechanical action of the brush as tests on glass and polished steel clearly prove, whereas the latter is not eliminated and rusting starts underneath the paint coatings. EF (13)

Internal Corrosion of Natural Gas Pipe Lines. Elmer F. Schmidt & Thomas S. Bacon. *Oil Weekly*, Vol. 75, Oct. 22, 1934, pages 25-30. Paper read before the Natural Gas Department of the American Gas Association, Atlantic City, Oct. 29. After dealing with the causes of corrosion the following ways of eliminating or alleviating the damage are discussed: Protection of the pipe metal by applied coatings, use of pipe metal alloys, dehydration of the gas, removal of oxygen and hydrogen sulphide from the gas, addition of inhibitors to the gas. Kz (13)

Nickel and Its Alloys in Refining of Petroleum (Das Nickel und seine Legierungen in der Petroleumraffinerie). R. W. Müller. *Korrosion & Metallschutz*, Vol. 10, Dec. 1934, pages 288-289. Refining of petroleum requires materials highly resistant to chemical corrosion and high temperatures. Monel metal, alloys of Cu and Ni, usually 30% Ni and 70% Cu, Inconel and Ni-plated steel, Ni steels and special castings with Ni have been found satisfactory. A cast Fe of high mechanical strength and hardness is made with 4.5% Ni and 1.5% Cr; the hardness is 500-750 Brinell. Recently an austenitic cast Fe with 14% Ni, 6% Cu, and 1.5% or more Cr has proved to be of excellent quality in refineries. Ha (13)

Pumping Corrosive Liquids. D. G. McNair. *Industrial Chemist*, Vol. 10, Nov. 1934, pages 442-446. The design of pumps is discussed. Metals used in construction are referred to briefly. RAW (13)

A New Corrosion-Resisting Alloy. H. Kalpers. *Gas Journal*, Vol. 205, Mar. 21, 1934, page 753. Abstract of article published in *Brennstoff-Chemie*, Vol. 15, Mar. 1, 1934, page 98. The article refers to a new alloy, Corrix-Metal, composed of 88.1% Cu, 8.7% Al, and 3.05% Fe. The metal is of high purity, is a eutectic, and is made by a special melting process. It can be cast and drawn. It has good resistance to H_2SO_4, sea water, alkalis and steam. It is not very resistant to HCl and NH_4Cl. It has a tensile strength of 41 to 44 tons/in.^{2} and an elongation of 25 to 35%. MAB (13)

Pumps for Marine Service. F. M. Jones. *Transactions Institution of Marine Engineers*, Vol. 46, June 1934, pages 157-169. Paper read before a Meeting of the Junior Section of the Institution of Marine Engineers, Nov. 9, 1933. The application of cast iron, gun metal, bronze, and stainless steel for pumping parts is briefly discussed. Various alloys have been tried to prevent corrosion by sea water and brine, but best results have been obtained by the use of cast iron with additions of Ni, Cu, and Cr. Kz (13)

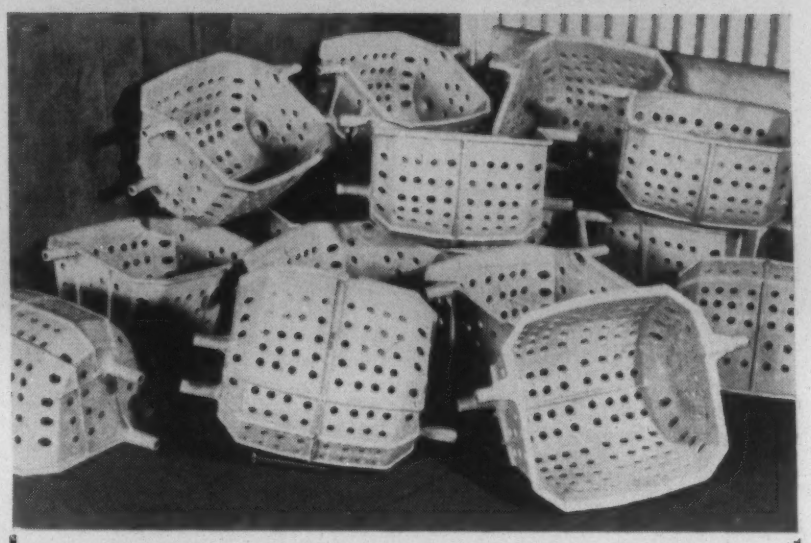
Alternating Current Corrosion (Ueber Wechselstromkorrosion). I. S. Jellinek. *Elektrotechnik & Maschinenbau*, Vol. 52, Dec. 9, 1934, pages 577-580. Attention is called to a peculiar phenomenon of corrosion by a.c. which in its whole appearance is very similar to d.c. corrosion. In all cases a gas was observed the composition of which approached oxy-hydrogen and can lead to explosions. This corrosion occurred both on living matter and metals. Some cases and tests to explain them are described. **Alternating Current Corrosion (Systematik der Wechselstromkorrosion) II.** H. Hohn. Pages 580-583. Further investigations make it probable that the electrolytic attack of metals by a.c. is due to a precipitation of foreign material; the corrosion increases with voltage, current and wave length. The material of the electrode is of importance as the logarithm of the corrosion is proportional to the normal potential of the electrode material. According to the kind of electrolyte 3 different types of corrosion are distinguished: metalloid, hydrogen and complex corrosion. If anions are present in the electrolyte which form difficultly soluble compounds with the electrode material, passivation can be obtained and corrosion prevented. 11 references. Ha (13)

Formation of Protective Layers on Copper (Beitrag zur Frage der Bildung schützender Schichten auf Kupfer). L. W. Haase. *Zeitschrift für Metallkunde*, Vol. 26, Aug. 1934, pages 185-188. A microscopic and chemical examination of natural patina and artificial corrosion coatings on Cu has led to the conclusion that the protective agent is Cu_2O in all instances. Micrographs show that the green compounds in a patina cover only a small portion of the total surface of the Cu, whereas the Cu_2O forms a continuous layer. The chemistry of natural and artificial patina formation is discussed. It is demonstrated that oxygen must be present in water for the formation of patina in pipes. An analytical procedure for the quantitative determination of cuprous oxide in such coatings is described. 12 references. FNR (13)

Corrosion and Protection of Metals (La Corrosion et la Protection des Métaux). U. R. Evans. *Chimie et Industrie*, Vol. 32, Special Number, Apr. 1934, pages 158-167. The author reviews the causes of corrosion and discourses on the theory of "susceptible points." He reviews the various methods of protection against corrosion: the use of resistant materials, preliminary treatment, and application of metallic and non-metallic coatings. MAB (13)

ALCUMITE

Pickling Baskets



16 PICKLING BASKETS of an order for 50, for a prominent Detroit manufacturer. They weigh about 45 lbs. each, and measure, inside, 14" x 14" x 10" deep.

What's ALCUMITE?

ALCUMITE is an aluminum-bronze alloy resistant to a large number of corrosive chemicals and solutions.

It is especially recommended for sulphuric acid under non-oxidizing conditions; for concentrations as high as 80% up to 200°F., and as high as 60% up to 250°F. It is resistant to a wide range of organic acids; animal and vegetable oils; sludge acids; and to many sulphates, chlorides and other salts.

Alcumite is available in cast forms and hot rolled bar. It can be machined with the same equipment used for steel and is adaptable to mechanical processing.

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14. APPLICATION OF METALS AND ALLOYS

Metallic Insulators Are Effective Heat-Ray Traps. JOSEPH F. SHADGEN. *Iron Age*, Vol. 135, Feb. 14, 1935, pages 10-16. Gives technical information on insulation for heat and cold using low emissivity steel surfaces with large air spaces. The emissivity values of metals are plotted against the lengths of various vibrations in zone between 0.5-.10 microns. Al and steel have a chance to be adapted to designs reflecting the heat rays effectively. Zn and Cu have only potential values at present. Pb, Sn and Ni are eliminated from consideration. Effective heat ray traps can be made by using properly selected surfaces of low emissivity and high reflectivity separated by air spaces. Considers massless type of insulators. VSP (14)

Metals in Building Industry II (Das Metall in der Bauwirtschaft II). *Die Metallbörse*, Vol. 32, May 30, 1934, pages 677-683; June 2, 1934, pages 697-698; June 9, 1934, pages 729-730; June 16, 1934, pages 762-763. A new series of articles (See also *Metals & Alloys*, Vol. 5, Nov. 1934, page MA 542 L 4) on the utilization of metals and alloys for structural purposes comprises the following papers which must be consulted for further information: **Steel and Its Significance for Modern Structural Work (Der Werkstoff Stahl und seine Bedeutung für das neuzeitliche Bauen).** OTTO VON HALEM; **The Latest Developments in Molybdenum Bearing Alloy Steels (Die neueste Entwicklung der molybdänhaltigen Edelstahlsorten).** Anonymous; **Magnetic Soft Ferrous Alloys in Electrical Engineering (Die magnetisch weichen Eisenlegierungen in der Elektrotechnik).** W. BERNDT; **Non-Ferrous Metals in Electrical Engineering (Die Nichteisenmetalle in der Elektrotechnik).** R. SCHULZE; **Copper and Copper Alloys in Structural Work (Kupfer und Kupferlegierungen im Bauwesen).** SCHIMMEL; **Utilization of Zinc in Building Industry (Die Verwendung des Zinks in der Bauwirtschaft).** W. FASSBENDER; **Aluminum in Architecture and House Building (Aluminium in Architektur und Hausbau).** WALTHER ZARGES. EF (14)

Repowering the "Asturias." *Marine Engineer*, Vol. 57, Nov. 1934, pages 302-307. Discusses the new engine and boiler equipment and the application of the different metals and alloys. Kz (14)

14a. Non-Ferrous

G. L. CRAIG, SECTION EDITOR

Pouring vs. Spraying Babbitt. A. HOYT LEVY. *Metallizer*, Vol. 3, Nov. 30, 1934, page 3. Sprayed bearings are said to have the advantages of a tightly adherent bond between lining and backing, a homogeneous babbitt lining free from hidden blowholes or porosity and to be adapted to the production of very thin linings for severe heavy load service. It is only recently that satisfactory babbitt wire has been drawn suitable for use in metal spray pistols. Backings are prepared for metal spraying by sand blasting. BWG (14a)

Cast Aluminum Protects Monument. *Foundry*, Vol. 63, Feb. 1935, pages 25, 56. Recent inspection of tip of Washington monument which has seen 50 years of service, showed it is still in good condition. The tip is composed of 98% Al, 1% Fe and 1% Si, Mn, Cu, Sn and Na. VSP (14a)

Aluminum Masts for Racing Craft Find Favor in Cup Contests. *Iron Age*, Vol. 134, Dec. 13, 1934, pages 20-23. Describes the Al mast used on yacht Rainbow. The mast was designed so that point of balance was 69.3 ft. from bottom when weighed horizontally. At top of mast the Al is only 1/6 in. thick. Rivets and bolts along the mast, and welding at critical joints insure strength. Discusses also Al installations on other vessels. Includes glossary of yachting terms used in the article. VSP (14a)

Light Metals in Truck Construction (Leichtmetalle im Lastwagenbau. Les métaux légers dans la construction des camions). M. KOENIG. *L'Allégement dans les Transports*, Vol. 3, Sept./Oct. 1934, pages 106-108. In German & French. The increased use of light metal alloys in Switzerland promoted by certain specifications in recent Swiss laws and due to excellent practical experiences with low-weight busses are pointed out. The weight reductions of various truck parts due to the adoption of Duralumin are discussed and structural details are shown. EF (14a)

Aluminum in the Building Trade (Aluminium im Bauwesen). E. HERRMANN. *Aluminium*, Vol. 17, Jan. 1935, pages 20-28. Types of Al and Al alloys used in the building trade are discussed and examples of structures, fixtures, ornaments, etc., are shown. Ha (14a)

Palladium-Copper Alloys in Industry. E. E. HALLS. *Industrial Chemist*, Vol. 10, Aug. 1934, pages 313-314. Cu-Pd alloys are used in manufacturing some types of electrical contacts for minimizing cratering or building up. The 60% Pd 40% Cu is generally used. Another feature of this alloy is its comparatively high hardness values as compared with other precious metal contact materials of the Pt group, especially that of Pt-Ir. Methods of chemical analysis given. RAW (14a)

Platinum Consumption Increased During 1934. CHARLES ENGELHARD. *Metal & Mineral Markets*, Vol. 6, Jan. 17, 1935, page 3. World consumption of Pt metals for 1934 about 200,000 oz., an increase of approximately 15%. Applications included Pt-Rh alloy catalyst in the manufacture of nitric acid; increasing use of Pd alloys in dentistry and jewelry, and many new fields for Pd leaf. Rh plating also made good progress. BHS (14a)

Copper in Weights and Measures (Le Cuivre dans les Poids et Mesures). V. BRIARD. *Cuivre et Laiton*, Vol. 8, Jan. 15, 1935, pages 17-19. Review. Ha (14a)

Wide Outlet of Cadmium in New Bearing Alloys. *Metal & Mineral Markets*, Vol. 6, Jan. 3, 1935. Excellent results are claimed for Cd-base alloys, and at least one popular car will be equipped with such bearings in 1935. A new Cd-Ag-Cu bearing has been introduced which is said to give better service for high-compression motor bearings than babbitt metal. A Cd-base alloy with 1.3% Ni is also used in several cars. BHS (14a)

Aluminum for Roof Coverings (Aluminium für Dacheindeckungen). R. HAEFNER. *Metallwirtschaft*, Vol. 13, Nov. 9, 1934, pages 786-789. Since the use of Cu as a building material has been considerably reduced by law, Al is the best material to take its place. In laboratory corrosion tests with .1% H_2SO_3, Al was slightly better than Cu, and much better than Zn and galvanized steel. On account of their higher strength Al alloys with good corrosion properties are used in preference to pure Al. Roofs made of Al cannot be fastened down the same as Cu. A method of holding down Al roofs which has been very successful is the use of a bituminous binder between the roof and the Al sheets. CEM (14a)

14b. Ferrous

M. GENSAMER, SECTION EDITOR

Materials Economies in Light Weight Railway Cars. E. J. W. RAGSDALE. *Railway Age*, Vol. 98, Jan. 12, 1935, pages 52-54. The weight-strength relation of construction materials is stressed. The newer alloy steels belong to weight reduction as distinguished from true light-weight construction. Increase in speed increases safety requirements. Safety factor for equipment at 60 miles per hour is about four, high speed streamlined train factor should not be less than six. The higher factor is obtained only with the stainless steels. Calculations are made for economies due to use of stainless in Zephyr train in comparison with lower alloys. WB (14b)

Can We Expect Better Rails? J. R. MOONEY. *Railway Age*, Vol. 98, Jan. 12, 1935, pages 40-42. Rail C content determined by experience by each particular railroad is at point of maximum performance. Demands for greater service can be met now only by heat treatment or use of alloys. The rail ends take the brunt of service and are usually battered before heat treating crew gets to newly laid rail. At the mill the rail ends are hardened by quenching before they have cooled or by subjecting to electric resistance heating after rails have cooled, then quenched after reheating. Shatter cracks have been eliminated at the mill by prolonged cooling. This gives slightly lower hardness but greater toughness. Other processes are described but Mackie's gives best results. WB (14b)

Wrought Iron and Steel in Tanker Construction. WARNER LUMBART. *Marine Engineering & Shipping Age*, Vol. 39, Dec. 1934, pages 448-452. Facing the solution to the problem of tank ship corrosion, the tanker operator is confronted with 3 alternatives: (1) the use of mild steel and the acceptance of its short life, (2) the use of protective coatings, (3) the use of more durable materials. After dealing with the problem of corrosion a proposal to use composite steel and wrought iron construction is made. Discussing the economic side of the question the author shows that the use of wrought iron for the tank section, where the corrosion problem is more acute, with steel construction elsewhere, presents a practical improvement. Kz (14b)

New Designs Demand Improved Steels. EDWIN F. CONE. *Machine Design*, Vol. 6, Dec. 1934, pages 31-34, page 69. Discusses low alloy (4% max.), high-tensile steel. Six tables collect data on physical properties and chemical components of 2 and 3.5% Ni steel (as rolled), Cr-Mn-Si steels, Cr-V steel (plates after annealing) low alloy Mo steel (Mn-Mo and Si-Mo steel) in the "as rolled" state and special high tensile steels. The discussion also includes medium Mn steel, Cu steels with 1.25-1.75% Cu, Mn-V, Cr-Si-Cu, Mn-Cu-Si (.35% C) and Mn-Si steel with 0.4% C. Experiments are under way on a 1.-1.25% Cu, .2-.3% Mo steel, and on 1.25-1.75% Cu steels with small amounts of Ni. The corrosion resistance of Cr-Si-Cu steel is 4-6 times larger than that of ordinary open-hearth steel with respect to atmospheric attack. WH (14b)

Iron Casting in the Automobile (La Fonderie de Fonte dans l'Automobile). BROCHETON. *Usine*, Vol. 43, Dec. 27, 1934, pages 27-29. The various types of ordinary and alloyed cast Fe used at present in the different parts of automobiles (French and foreign) are reviewed, composition and heat-treatment briefly described. Ha (14b)

Needle Bearings—Newest Anti-Friction Aids. *Electrical Manufacturing*, Vol. 14, Jan. 1935, pages 20-22. Higher load capacity, smaller space, less lubricating necessary, lower cost are advantages of new needle bearings. They will be applied to electric motors where they may be sealed with lubricant for life of appliance. WB (14b)

Sectional Sheet-Steel Poles. *Electrical Review*, Vol. 115, Nov. 2, 1934, page 604. Describes telescopic poles for power transmission and telegraph lines which consist of galvanized, welded sheet-steel sections, each 2 m. long, conical in shape, and elliptical in cross-section. They are constructed of special corrosion-resisting steel sheets with a tensile strength of 60-70 kg./mm.^{2} MS (14b)

Anchoring the 534. *Engineer*, Vol. 158, Sept. 14, 1934, page 267. Brief illustrated article on manufacture and tests made on anchor cables to be used for the "534." The links of the cables are 2 ft. long and 4⅛" in diameter forged in 2 pieces and after they are threaded together they are put through an electric welding machine which joins the pieces together. LFM (14b)

Factors in Redesigning for High-Strength Steel Sheets. V. H. Lawrence. *Product Engineering*, Vol. 6, Feb. 1935, pages 51-53. When designing for light weight the selection of a material of high strength is of importance. Examples show points to be taken into account and how fabricating methods influence the selection. For fusion welding heavy sections and plates the following maximum limits in chemical composition are generally adopted: C 0.31%, Mn 0.75%, Si 0.25%, S 0.05%. A schedule is given which facilitates the selection. Ha (14b)

Alloy Steel Axles for Locomotives. Frederico Giolitti. *Metal Progress*, Vol. 27, Feb. 1935, page 43. Describes difficulties experienced in European use of Cr-Ni steels for locomotive axles and the adoption of Cr-Mo steel for this purpose. WLC (14b)

Notes on Railway Laminated and Coiled Springs. W. E. Frost. *Inspection*, Vol. 5, Apr. 1934, pages 24-30, including comment; reply to the comment: July 1934, page 9. Analyses and brief discussion of 8 spring steels (C, Si-Mn, Cr-V steels) and their heat treatment. The design and testing of laminated and coiled springs is dealt with. In the reply to the comment, criticizing the percentages of Mn and C given ,the author says that owing to the high stresses imposed on springs during testing, it is an advantage to keep the Mn in the neighborhood of 0.80% for laminated and 0.75% for helical springs. The small range of 0.02%-0.05% C is called desirable from the spring maker's standpoint. Kz (14b)

5% Cr Still Tubes Service Records are Satisfactory. E. S. Dixon. *Metal Progress*, Vol. 27, Feb. 1935, pages 33-36. Describes typical failures of C steel still tubes and the advantages of Cr steel in its resistance to H_2S. While the creep strength of 5% Cr steel is same as C steel at operating temperatures, its greater short time ultimate strength results in warning and greater safety under adverse conditions. Use of this steel has resulted in reduced number of failures. Describes welding procedure for this air hardening steel which involves preheating and maintaining above 300° F. during the welding and subsequent anneal at 1600° F. Ductility and impact resistance of this steel at operating temperatures are decided advantage. WLC (14b)

Welded Cromansil Structures in Railway Service. E. J. Charlton. *Railway Mechanical Engineer*, Vol. 109, Jan. 1935, pages 17-20. It is shown how parts fabricated by welding not only permit weight reduction but also proper stress distribution. The cromansil steel used contains 0.17-0.22% C, 0.4-0.6% Cr, 1.0-1.4% Mn, 0.6-0.9% Si, and has a yield point of 50-60,000 lbs./in.², an ultimate strength of 80-90,000 lbs./in.² and an elongation of about 28% in 2". Ha (14b)

Soil Erosion Check Dams Require Considerable Steel. *Steel*, Vol. 95, Oct. 8, 1934, page 35. Check dams for controlling soil erosion require steel reinforcing bars, wire, woven wire fence, fence posts, and cable. Individual requirements of each job usually are small, but in the aggregate they are large. Needs vary with district. Describes several types of temporary dams, in which wire, woven wire, and cable are used. MS (14b)

Large Uses of Steel in Small Ways. No. 268. 600 Tons of Steel Annually for Socket Wrenches. *Steel*, Vol. 95, Aug. 27, 1934, page 42. Outline of the manufacture of detachable socket-wrenches. They are made largely from cold-rolled bars, alloy steel usually being used for better grades. Ratchet handles are completely drop forged. Other accessories are partially forged. Sockets are machined. MS (14b)

Large Uses of Steel in Small Ways. No. 269. Electric Irons. *Steel*, Vol. 95, Sept. 10, 1934, page 40. About 4000 tons of steel, principally flat-rolled stock, and an equal or greater quantity of cast-Fe are used annually in the manufacture of domestic electric irons. Describes principal features. MS (14b)

Large Uses of Steel in Small Ways. No. 270. Vending Machines. *Steel*, Vol. 95, Sept. 24, 1934, page 51. In active business years more than 1500 tons of steel are consumed annually in fabricating the hundreds of types of automatic vending-machines. Furniture sheets are used for cases. Terne-plate is used for chutes in candy, cigarette, and gum machines. Cold-rolled strip and wire are also used in certain units. MS (14b)

Large Uses of Steel in Small Ways. No. 271. Perforating Machines. *Steel*, Vol. 95, Oct. 8, 1934, page 55. More than 50 tons of iron and steel are consumed annually in this industry, the larger portion being in the form of castings. Frames usually are of cast-Fe, while steel is used for the principal parts of the perforating mechanism. Products used include music wire, mechanical tubing, strip, tool steel, and shafting. MS (14b)

Large Uses of Steel in Small Ways. No. 272. Turnstiles. *Steel*, Vol. 95, Oct. 22, 1934, pges 46, 48. Flat-rolled products, such as plates and sheets are the principal steel items consumed in the manufacture of turnstiles, although bars, tubing, and castings represent a good proportion. Stainless steel is finding increasing application for certain parts. Describes principal features of various types. MS (14b)

Large Uses of Steel in Small Ways. No. 273. Steering Gears. *Steel*, Vol. 95, Nov. 5, 1934, page 62. In recent years, 20,000-65,000 tons annually of steel forgings, tubing, and bar stock have been used annually for steering-gears, in addition to a substantial tonnage of malleable castings. Describes cam and lever type of automobile steering-gears. MS (14b)

Large Uses of Steel in Small Ways. No. 274. Car Spotters. *Steel*, Vol. 95, Nov. 19, 1934, page 45. About 250 tons of cast-Fe, and rolled, forged, and cast steel are consumed annually in the manufacture of car spotters. Some non-ferrous metals are also used. MS (14b)

Improved Meat Choppers Are Made of Chromium Plated Alloy Cast Iron. *Steel*, Vol. 95, Dec. 17, 1934, page 39. Hobart Mfg. Co., Troy, O., uses cast-Fe containing 14% Ni, 5% Cu, 1.25% Cr, 1% Mn, and 3% C, for bodies, worms, and rings of meat-choppers and for spray heads, drain-valve bodies, and other parts of dish-washers and potato peelers. Alloy is stronger, more corrosion resistant, and takes better polish for Cr plating than ordinary gray cast Fe. Drawn steel and stainless steel also are used in the meat-chopper. MS (14b)

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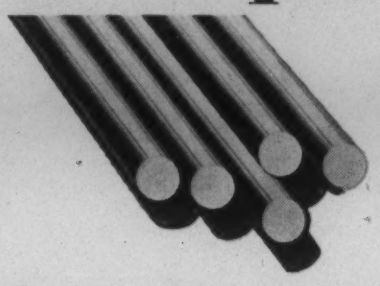

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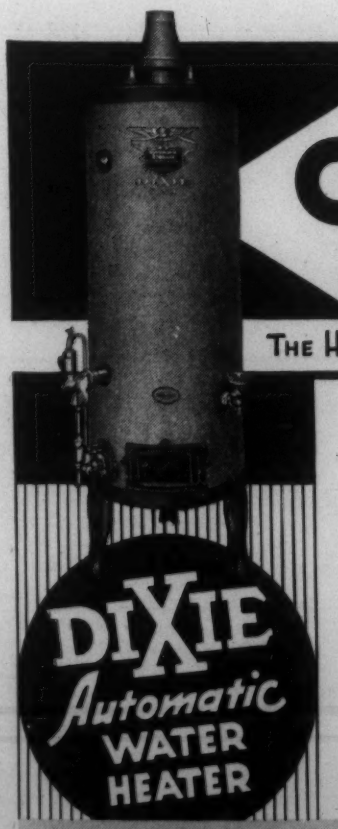

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15. GENERAL

RICHARD RIMBACH, SECTION EDITOR

Die Castings. HERBERT L. CHASE. John Wiley & Sons, Inc., New York, 1934. Cloth, 6 x 9¼ inches, 264 pages. Price $3.50. This timely book fills a growing need on the part of the designer for detailed, authentic information on the subject of die castings. Mr. Chase has succeeded admirably in the difficult task of compiling from original sources a great deal of detailed information on the various phases of die casting. In his preface Mr. Chase points out that, in view of the coöperation which he received from the die casting industry and from the large alloy and raw material producers—"This book may, therefore, be said to represent a composite of information drawn from those best qualified to speak on the subjects treated, as well as to include the latest information available for publication on these subjects." The latter phrase is one which expresses a limitation common to all books dealing with growing arts. The subject material is contained in 6 chapters each dealing with a specific phase of the problem. The first 2 chapters are devoted to a discussion of the advantages and limitations of the die casting process with numerous photographs of typical applications accompanied by comments as to the particular advantages which resulted from the adoption of die castings. Designers are almost certain to find here applications which suggest solutions to some of their own problems. Chap. 4 considers the matter of die design and die casting technique in sufficient detail to enable the designer to take the fullest advantage of the unique possibilities of this process. Detailed data on the physical and mechanical properties of the available alloys and a comprehensive discussion of specifications and acceptance tests will be found in Chaps. 3 and 5. The methods used in the application of plated coatings and organic finishes are considered in Chap. 6. The book should furnish the background necessary to appreciate the suggestions of the die caster. It should prove of great assistance to the designer and the engineer and warrants a place on the drawing table. E. A. Anderson (15)—B—

What Mass Acceptance of Household Appliances Will Mean to Industry. *Steel*, Vol. 95, Sept. 17, 1934, pages 25-27, 50. Adoption by household appliance manufacturers of the automobile industry's policy of large volume at low profit to reach the low-income-group market seems likely to result in mass consumption. This will impose many changes in the functioning of the metal working industries, the most drastic being those arising from price. It will serve as a powerful incentive for low cost production of materials and parts. It behooves the metal working industries to cooperate with the appliance industry in developing materials, parts, and services. MS (15)

Appearance—In Design and Color—Helps Sell Fabricated Products. *Steel*, Vol. 95, Oct. 1, 1934, pages 25-28. Discusses and presents examples of improvement in appearance of machine-tools, machinery, household equipment, and other fabricated metal products by redesigning them and use of paint, lacquer, metal plating, enamels, and other finishes. MS (15)

The Metallurgist in the Gear Industry. FRANCIS W. ROWE. *Heat Treating & Forging*, Vol. 20, Aug. 1934, pages 387-389. Outline of the duties of the metallurgist. MS (15)

Beryllium Developments and the Outlook for Supply. C. B. SAWYER. *Mining & Metallurgy*, Vol. 15, Feb. 1934, pages 93-94. Includes a brief bibliography. Describes the recent developments of the use of Be as an alloying element with Cu, the application of BeO as a refractory, and although not yet in commercial form, it is used in metals other than Cu, such as Ni and steel, as a precipitation hardening agent. A recent important finding of the National Physical Laboratory in England was that Be is ductile when pure. As to source of supply of Be, author states that the greatest problem will be to find and develop the deposits. At present there seems to be no known source to supply 10 tons of pure gangue-free beryl, although this ore is widely distributed. Indications are that such ore supplies exist. VSP (15)

Diffusion of Hydrogen Through Platinum and Nickel and Through Double Layers of These Metals. W. R. HAM. *Journal of Chemical Physics*, Vol. 1, July, 1934, pages 476-481. Flow of H_2 through single sheets of Ni and Pt with atmospheric pressure on ingoing side and 0.1 mm. pressure on outgoing side follow the empirical equation $R = A\ (p_o^{.5} - p_t^{.5})/x)\ T^{-.5}\ .\ \epsilon^{-b_1/T}$ similar to that of Borelius where p_t is small compared with p_o but apparently proportional to p_o. With double layers of these 2 metals, the b_1 of the exponent is dependent only on the metal at the outgoing surface and is the difference between the work of escape from the outgoing surface and the heat of solution of H in that metal. The kinetic theory flow equation is sufficient to explain the p_t and the variation of p_t with temperature may be used to compute the work function at the outgoing surface and also to obtain values of m/k when m = mass of H atom and k = Boltzmann constant. EF (15)

New Developments in Metallurgical Research (Nyheter paa Metallforskningsomraadet). JOH. HÄRDÉN. *Teknisk Tidskrift*, Vol. 64, Nov. 17, 1934, pages 431-433. A brief review of recent metallurgical developments, including investigation of magnetic properties of very thin Ni deposits; deposition of black Ni plate; use of SiAl alloys for pistons in explosion motors; studies of the phase diagram of V-Ni-Fe alloys; and the use of isoperme, an Fe-Ni alloy of the permalloy type as core material in pupin coils, instead of the pressed Fe-Si alloys generally used for this purpose. BHS (15)

Electric Purification of Gases (Zur elektrischen Gasreinigung). GUSTAV KROUPA. *Montanistische Rundschau*, Vol. 26, Dec. 16, 1934, 3 pages. A description of the Whessoe procedure for electric precipitation of tar and dust from metallurgical gases. In the tar precipitator a removal of 99% of the tar is accomplished, with a power consumption of 1 kw. per 100,000 ft.³ of gas. Suspended pipes are used for electrodes in the removal of tar, while for removal of solid dust a compact arrangement of blocks of connected hexagonal pipes has been found most suitable. A removal of 99.5% is accomplished in the case of dust; the apparatus may be used for all temperatures up to red heat. BHS (15)

Mines. Agenda Dunod 1935. E. STALINSKY. Dunod, Paris, 1935. Cloth, 4 x 5¾ inches, 335 pages. Price 23.80 Fr. Similar handbook to the metallurgical Agenda Dunod, dealing with mining methods and equipment. The only metallurgical discussion relates to rock drills. H. W. Gillett (15)—B—

Metallurgie. Agenda Dunod 1935. R. CAZAUD. Dunod, Paris, 1935. Cloth, 4 x 5¾ inches, 340 pages. Price 24.40 Fr. Very general brief discussion of a large number of topics in both smelting and physical metallurgy, ferrous and non-ferrous. Not all of the information is accurate, for example under endurance the method of stepping up the load on a single test bar is advocated, without comment as to the effect of strengthening by understressing. Some French specifications, as those for structural steel, are given. Rules under the French labor laws cover 84 pages and there are 63 pages of tables. The book has some interest as exhibiting the French point of view but would not be a substitute for the better American handbooks. H. W. Gillett (15)—B—

Wire Rope Research (Drahtseilforschung). R. WOERNLE. *Zeitschrift Verein deutscher Ingenieure*, Vol. 78, Dec. 29, 1934, pages 1492-1498. At the 10th meeting of the committee for wire rope research of the VDI reports were made on the newest investigations on influence of form of groove, corrosion and rigidity of the rope; further on the interior condition of ropes with regard to fracture and corrosion, influence of diam. of drum and torsion, and distribution of stresses in ropes which run over several drums or sheaves with different angles of circumferential contact. The often averred inferiority of galvanized wires to bare wires could not be corroborated. The influence of the construction of the rope, i.e. different groups of strands, and torsion-free ropes were treated theoretically and experimentally. The additional stresses to the tensile stress by bending which are of importance in ropes for cranes, elevators, etc., can be reduced or favorably influenced by proper grouping of strands. 32 references. Ha (15)

Arsenic. PAUL M. TYLER & ALICE V. PETAR. *United States Bureau of Mines, Economic Paper* 17, 1934, 35 pages. The properties, uses, extraction, production, etc., of As are described. AHE (15)

Regarding Ferro-phosphorus (A propos du ferro-phosphore). *Journal du Four Electrique*, Vol. 43, Dec. 1934, page 436. In the article on Fe-P published in *Journal du Four Electrique*, Nov. 1934, a remark was made that the transportation of the alloy is connected with danger. Anonymous author states that no inconvenience was ever felt in transporting it. French railroads do not classify it as dangerous, though French steamship lines do not accept it for transportation. JDG (15)

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15a. Economic

Minerals Yearbook 1934. O. E. Kiessling et al. United States Bureau of Mines, Washington, 1934. Cloth, 6 x 9¼ inches, 1154 pages. Price $1.75.

In 1933 the protracted decline of the mineral industries of the world as a whole was sharply checked. By the end of 1932, the mineral production of the world, except Au and petroleum, had receded steadily and rapidly for 3 years so that the combined production of the chief industrial metals—Cu, Pb, Zn, Al, Sn and Ni—was 64% its average amount for 1925-1929; pig Fe had shrunk to 45% of its 1925-1929 average. The total value of production was 46% of its 5 year average. In 1933 this rose to 54%. Production of the chief industrial metals rose to 68% (from 64%); pig Fe increased to 57% (from 45%). Only Au and Ag decreased, Au from 124 to 123% and Ag from 65 to 64%. In the U. S., 1933 total values were the same as 1932. In 1933, U. S. production of Cu was 25% of the base period, Ag 36%, Fe 38%, Pb 39%, Zn 52%, Al 49%. For the rest of the world, the corresponding figures were 100%, 73%, 76%, 86%, 92% and 66%. The 1933 production of the following is given, compared with foregoing years, and discussed: Au, Ag, Cu, Pb, Zn, Fe, Al, Hg, Mn, Mo, W, Sn, Cr, Sb, As, Ra, U, V, Pt and allied metals, minor metals, Ni, and secondary metals. Ore concentration and governmental actions influencing Au price are discussed. A. H. Emery (15a) —B—

Non-Ferrous Metals Today and Tomorrow. Zay Jeffries. *Metal Progress*, Vol. 27, Jan. 1935, pages 17-21. Discusses the economic trends in metal production and states that they pass through ages of Au, Ag, Cu, Pb, Zn and Fe and that each metal experiences development in a given area where exports of crude ore, number of mines, number of smelters, production of metal and imports of crude ore are successively at maxima. Europe and N. America are in the latter stages of the Fe age while Africa and S. America are still in second phase of Cu age. Long range trends indicate that Al will eventually be largest tonnage nonferrous metal but will not exceed iron. Short range trends suggest that engineering suitability will become of increasing importance in metal selection with increased use of nonferrous metals. WLC (15a)

Automobile Steel and Geography. W. Trinks. *Blast Furnace & Steel Plant*, Vol. 22, Oct. 1934, page 587. Suggests establishment of automobile factories near existing steel-works. MS (15a)

Mineral Industry of Yugoslavia. H. K. Scott. *Iron & Coal Trades Review*, Vol. 129, Dec. 14, 1934, page 937. Brief review of principal resources in coal and ores of Fe, Cr, Cu and Al; geological conditions are described. Ha (15a)

Russian Copper. Guy C. Riddell & G. D. Jermain. *Engineering & Mining Journal*, Vol. 135, Dec. 1934, pages 547-551. Ural reserves now supplying ¾ of the Soviet Union's Au output, contain but ¼ of the country's total estimated tonnage of Cu. The other sources are at more distant points—Kazakstan and Central Asia, Siberia, Transcaucasus and the Kola Peninsula. WHB (15a)

Use of Electricity in the German Iron and Steel Industry (Aus der Elektrizitätswirtschaft der deutschen Eisenhüttenwerke). H. Euler. *Archiv für das Eisenhüttenwesen*, Vol. 8, Nov. 1934, pages 197-204. Statistics on the consumption of electricity in 112 German iron and steel works for 1929 to 1932, and a discussion regarding generating current or buying it outside; in general it is recommended that a plant should put itself in a position to generate its own current. SE (15a)

Ores and Industry in South America. H. F. Bain & T. T. Read. Harper & Bros., New York, 1934. Cloth, 6 x 8¾", 381 pages. Price $3.50. Will the South American countries develop metallurgical industries in which finished products will be made for export, or will they continue to supply raw materials to other countries? The authors discuss this question, country by country, in most interesting fashion. History, geology, the nature of the people and of the government and all the factors entering into the economics of the broad situation are considered. The development through research of other sources of supply or of methods of utilizing other deposits has an important bearing on the retention of an apparently stable market for a mineral product. This is vividly traced in respect to Chilean nitrate and iodine. The iron and non-ferrous metal resources are discussed in adequate detail. The final conclusion is that it is unlikely that South America will become industrialized in any rapid or spectacular fashion. Instead, it will be more profitable for them to supply raw material. This situation puts these countries on the side of peace in world affairs. The book closes with the comment that with no dizzy pace of industrialization to keep up, these countries will exert a conservative force of real value to mankind. This volume, one of a series sponsored by the Council on Foreign Relations, is one to be enjoyed alike by the metallurgist and the general reader. H. W. Gillett (15a)—B—

Development Trends in the Iron and Steel Industry. William Ashcroft. *Metallurgia*, Vol. 11, Dec. 1934, pages 35-36. Discusses condition of English steel industry and describes some new equipment. JLG (15a)

The Lepidolith deposits "Rozna" in Moravia as Lithium Ore Deposits (Das Lepidolithvorkommen "Rozna" in Mähren als Lithiumerz-Lagerstätte). F. H. Mohr. *Berg-und Hüttenmännisches Jahrbuch*, Vol. 82, June 25, 1934, pages 44-50. The deposits of lepidolith are of great extent and form one of the few important sources of Li on the earth. Its composition is usually $F_2KLiAl_2Si_3O_9$, with a Li content of 4.1%. The particular advantages of this mineral, in most cases occurring as pure pink colored mica, are its relative frequent occurrence and easy working with H_2SO_4; it contains also some Ru, Cs and Th. Li and its salts have found lately fairly wide application. The Al alloy "scleron" contains 0.1% Li; the bearing metal of the German State railways consists of 0.69% Ca, 0.62% Na, 0.04% Li, small amounts of Al, remainder Pb. Li is used as deoxidizer for Cu, Ni, and other metals and as addition to solders for Al. The ceramic industry uses lepidolith or Li minerals for production of milk-white glasses, and for glazes which must resist chemical attack or sudden temperature changes. It has found application also in pharmacy, photography and preparation of fireworks. Present yearly production of Li metal amounts to several 1000 kg., price about 165-175 MK. per kg. Geological conditions and mining possibilities are described; a list of references is included. Ha (15a)

Arsenic Industry in 1933—Advance Summary. A. V. Petar & C. N. Gerry. *United States Bureau of Mines, Mineral Market Reports* No. M.M.S. 303, Aug. 9, 1934, 2 pages. In 1933, 100,258 lbs. metallic As were imported into the U. S. for consumption as compared with 45,474 lbs. in 1932. Domestic production and other imports were of white As and various As compounds. AHE (15a)

1

Copper Industry in 1933—Advance Summary. H. M. Meyer. *United States Bureau of Mines, Mineral Market Reports* No. M.M.S. 292, July 13, 1934, 6 pages. Smelter production of Cu from domestic ores in 1933 declined 17% from 1932 and was 449,999,143 lbs. Refinery production from domestic ores, 481,338,031 lbs., was an increase of 8%. Stocks of Cu were 13% below those on hand at the end of 1932, but 19% above the av. for 1928-32. Imports declined 26% to 291,170,946 lbs., exports ncreased slghtly to 303,825,790 lbs., but were only 41% of the 1928-32 average. Domestic consumption increased 31%, but was only 56% of the 5 yr. average. AHE (15a)

Lead Industry in 1933—Advance Summary. H. M. Meyer. *United States Bureau of Mines, Mineral Market Reports* No. M.M.S. 286, May 24, 1934, 3 pages. The output of refined primary Pb in the U. S. from domestic ores in 1933 was 259,616 short tons, valued at $19,212,000 an increase of 2% in quantity and 25% in value over 1932, but 48% below the 1928-1932 average in quantity, 63% below the 5 yr. average value. Production of refined Pb from foreign sources was 13,963 short tons, a decrease of 58% from 1932. AHE (15a)

2

Tin in 1933—Advance Summary. Charles W. Merrill. *United States Bureau of Mines, Mineral Market Reports* No. M.M.S. 314, Sept. 19, 1934, 1 page. Domestic Sn output in 1933 was 2.4 long tons, valued at $2100. Most of this came from Alaska. Imports were 63,718 tons. Production from secondary sources was 19,732 tons. All figures are substantial increases over 1932. AHE (15a)

3

Abundance of Chromium and Manganese (Die Häufigkeit des Chroms und Mangans). G. von Hevesy, A. Merkel & K. Wuerstlin. *Zeitschrift für anorganische und allgemeine Chemie*, Vol. 219, Aug. 14, 1934, pages 192-196. The content of Cr and Mg was determined in more than 1000 mineral samples. Highest content of Cr is found in deep mineral strata, the least in essexites. Average Cr content in igneous rocks is 1 part Cr in 2000 parts of rock. Diorites have the highest, essexites the lowest Mn content, average is about 1 g. Mn in 1000 g. of rock. Ha (15a)

Possibilities of Export of Foundry Products (Ausfuhrmöglichkeiten von Giessereierzeugnissen). Joh. Mehrtens. *Zeitschrift für die gesamte Giessereipraxis*, Vol. 34, July 22, 1934, pages 299-300. Discusses possibilities of the German foundry industry of increasing foreign trade. Various reasons counteracting this aim are outlined. Aim can be attained only by processing high quality products. GN (15a)

4

Fluctuations in World Trade in Iron and Steel (Wandlungen im Welthandel von Eisen und Stahl). J. W. Reichert. *Stahl und Eisen*, Vol. 54, July 5, 1934, pages 709-712. Charts are shown giving yearly imports and exports of iron and steel of the five leading countries from 1909-1933, omitting the war years 1914-21. The total of exports and imports of the U. S. is considerably smaller than that of England, France, Germany, or Belgium. SE (15a)

5

Iron Ore Industry Periled by Tax and St. Lawrence Route. R. C. Allen. *Steel*, Vol. 95, July 30, 1934, pages 19-20, 39, 41. From address before the Ohio Section, American Institute of Mining and Metallurgical Engineers, June 22, 1934. Discusses political and economic aspects of the Lake Superior Fe-ore industry. Points out importance of an adequate supply of high-grade ores to the security, industrial strength, and self-sufficiency of the United States. Reserve of rich ore is limited. High-grade ore can be made from low-grade ore and can be delivered to furnaces now using lake ores at a cost which will permit its use there provided taxes and royalty are nominal and the natural geographic advantage of the mines be not destroyed by free passage of ocean freighters into lake ports. Taxes in Minnesota are discriminatory. Dominant political party there proposes confiscation of the mines. Cites statistics relative to the importance of the Lake Superior Fe-ore region. MS (15a)

6

The Mineral Industry During 1933. Edited by G. A. Roush. McGraw-Hill Book Co., Inc., New York, 1934. Cloth, 6½ x 9¼ inches, 745 pages. Price $12.00.

The 1933 issue of this book has 65 more pages than the 1932 volume. (See review in *Metals & Alloys*, Vol. 5, June 1934, page MA 301.) It is pointed out in the introduction of the book that Mineral Industry is not an original publication, but a summary of the statistical and technological progress of the year.

As far as possible each section is prepared by a specialist. In the compilation of the information free use is made of the current technical press, official and unofficial reports on production, consumption, exports, imports and markets.

This volume is not only a landmark for the present Editor because it marks the completion of 21 volumes under his direction, but also due to the thoroughness with which the job was done. The book should be in the hands of every company which requires such information. Richard Rimbach (15a) -B-

7

Metal Statistics, 1933. American Metal Market, New York, 1934. 27th Annual Edition. Cloth, 4 x 6 inches, 544 pages. Price $2.00.

The 1934 edition of this compact book contains statistics on ferrous and nonferrous metals for 1933 and preceding years. Tables showing the production, consumption, average prices, exports, imports, etc., are given. Richard Rimbach (15a) -B-

8

Needs Flexibility of Operation. Sam Tour. *Foundry*, Vol. 62, Jan. 1934, pages 21, 52. An economic survey of the non-ferrous industry and the formation of the Non-Ferrous Foundry Association for Industrial Recovery. VSP (15a)

Electrometallurgical Industries in Norway (Les industries électrométallurgiques en Norvège. Knudsen. *Journal du Four Electrique*, Vol. 43, Oct. 1934, pages 351-352. Statistics taken from Norges Offisielle Statistikk. JDG (15a)

9

The Steel Industry of Luxemburg (L'Industrie sidérurgique luxembourgeoise). A. Kipgen. *Revue Technique Luxembourgeoise*, Vol. 26, Sept.-Oct. 1934, pages 103-110. History, development and economical conditions are discussed. Ha (15a)

Light Metal Industry in Austria (Die Leichtmetallindustrie in Oesterreich). R. Mitsche. *Berg- und Hüttenmännisches Jahrbuch*, Vol. 82, Sept. 28, 1934, pages 85-89. Statistical data and comparisons with Fe and alloy steel production. Ha (15a)

10

Gold in 1933—Advance Summary. Chas. W. Henderson. *United States Bureau of Mines, Mineral Market Reports* No. M. M. S. 310, Oct. 8, 1934, 4 pages. Total Au production in the United States in 1933 was 2,552,459.85 oz., an increase of 38,702.95 oz. over 1932. All states except Colo., Nevada, Texas (8.66 oz.), Utah, Wash., and Ala. (64.87 oz.), increased output. AHE (15a)

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15b. Historical

The Story of Shropshire's Lead Industry. E. C. WADLOW. *Metal Industry*, London, Vol. 45, July 27, 1934, pages 75-77. A history of mines that retain evidence of having been worked by the Romans and continued intermittently until the late nineties when the falling price of lead made it impossible to work them at a profit. Apparently these mines had been worked for almost 2000 years and then stopped with little likelihood of a revival. HBG (15b)

An Historical Sketch of Copper Smelting. H. R. POTTS. *Metal Industry*, London, Vol. 44, May 18, 1934, pages 507-510. After a brief reference to the methods used back as far as 3000 B.C. the author gives some of the ancient history of the Rio Tinto mines. They were worked by the Phoenicians, Carthaginians and Romans, apparently for the Ag and Pb, for the slags left behind are higher in Cu content than would have been the case had this been the metal desired. He outlines the development of Cu smelting from prehistoric to present times and the development of the blast furnace from the first crude unit to those now in use. The process used in the reverberatory furnace, developed in Wales, consisting of 6 distinct operations, is cited as an example of highly specialized metallurgical operation. A rather complete description is given of fire refining of Cu which is still carried on in this manner. The difficulties of adapting the Bessemer converter to Cu smelting are discussed in some detail. This method of production revolutionized the industry and made the Welsh process obsolete from the standpoint of quantity production. The advantages of the vertical and horizontal types of converters are compared. HBG (15b)

The Development of the Modern Blast Furnace. ARTHUR G. MCKEE. *Iron & Steel Engineer*, Vol. 12, Jan. 1935, pages 1-15. Descriptive. WLC (15b)

Prehistoric Bronze Technique in Northern Germany (Vorgeschichtliche Bronzetechnik in Norddeutschland). JÖRG LECHLER. *Zeitschrift für Metallkunde*, Vol. 26, Sept. 1934, pages 206-207. An examination of bronze objects found in northern Germany and dated between 1000 and 2000 B.C. has indicated that the metal artisans of the bronze age understood alloying, the making of intricate castings, welding, and hot and cold working. FNR (15b)

A Note on the History of the Development of Ironfounding in the Sheffield District. J. E. HURST. *Foundry Trade Journal*, London, Vol. 51, Oct. 11, 1934, pages 219-220; Oct. 18, 1934, pages 241-243. Presidential address to the Sheffield branch of the Institute of British Foundrymen. First authentic record of iron castings in England is in connection with the manufacture of cannon at Buxtel in the year 1543. John Copley in association with William Astell and Francis Crofts, was granted a patent in 1627 including the "way and meanes for melting of iron oares and for makeing the same into cast works and barrs with seacoles and pittcoles in furnaces and fyneries with bellowes." The author refers to the invention of the cupola by W. Wilkinson, the casting of the Southwark bridge, the development of malleable cast iron, the commercial production of cast iron cutlery, etc. AIK (15b)

Ductile Tungsten (A Case History). SAMUEL L. HOYT. *Metals & Alloys*, Vol. 6, Jan. 1935, pages 11-18. Describes the development of ductile W for incandescent lamp filaments. WLC (15b)

Copper and Bronze in the Art of Medals (Le Cuivre et le Bronze dans l'Art de la Médaille). V. BRIARD. *Cuivre et Laiton*, Vol. 7, Dec. 15, 1934, pages 557-558. Historical sketch of technique of making medals and coins and of metals and alloys used. Ha (15b)

Effect of Developments of Structural Materials and Methods of Working Them on Boiler Construction (Einfluss der Entwicklung der Werkstoffe und Bearbeitungsarten auf den Dampfkesselbau). BLOCK. *Die Wärme*, Vol. 57, *Sonderheft*, Oct. 13, 1934, pages 674-679. The evolution of boiler constructions can be subdivided into 4 periods in which cast Fe, wrought Fe, mild steel and alloy steel dominated. Besides the improvement of boiler materials the advances of working the latter were also of decisive influence characterized by the utilization of machinery and metallurgical knowledge. The developments in bending, drilling, riveting, rolling-in and welding are discussed at length a great future being predicted for welding in boiler construction. Diagram is presented showing tensile strength and yield point of some 30 German boiler and tube materials at 20°, 250° and 450° C. States that the Mo-alloy steel enjoys a preferred place due to an increase of yield point and creep resistance at elevated temperatures without impairing the other physical properties. Similar effects are brought about by V. Cr, Cr-Si, Cr-Al steels (mostly with low additions of Mo) exhibit superior resistance towards scaling. EF (15b)

The Steel Ball: Early Methods of Manufacture. C. WATTS. *Engineer*, Vol. 158, Dec. 28, 1934, pages 634-636. Outline of the difficulties encountered in the early years of ball-bearing manufacture from 1876 when the first steel balls were made. The various processes in the manufacture are discussed and illustrated by drawings. LFM (15b)

Sheffield Steel. *Nature*, Vol. 133, Jan. 13, 1934, pages 49-51. Short history of development of steel making at Sheffield. CSB (15b)

Pruned Back, Republic Family Tree Still Is Luxuriant. *Steel*, Vol. 96, Jan. 7, 1935, pages 122, 262. Outlines history of Republic Steel Corporation. Genealogy (in supplement) shows steps in the growth of the organization. MS (15b)

The Story of Wire. F. W. BULLOCK. *Wire & Wire Products*, Vol. 10, Mar. 1935, pages 97-103. Origin and development of the wire industry is surveyed, processes described and statistics of production with particular reference to U. S. A. are given. Ha (15b)

Alloys Steels—An Historical Survey. HAROLD CARPENTER. *Metal Industry*, London, Vol. 45, Aug. 24, 1934, page 182. An abstract of a survey made by Sir Harold Carpenter and published by the Bureau of Information on Nickel. It is stated that copies of the survey may be obtained by application to the Bureau, The Mond Nickel Co., Ltd., Thames House, Millbank, London, S. W. 1. HBG (15b)

The Past, Present and Future of Cast Iron. W. R. JENNINGS. *Iron Age*, Vol. 134, Nov. 15, 1934, pages 16-19. Discusses the history of cast Fe from the time of the Egyptians, 6000 yrs. ago up to the present time. Considers also the various uses of cast Fe and stresses the importance of electric furnace in manufacture and treatment of the Fe. As to future development it depends on economic condition of the country. VSP (15b)

News and Personals

"Industry Meeting" of Gray Iron Foundrymen

An industry meeting of the Gray Iron Foundry Industry will be held Thursday and Friday, June 6 and 7, at the Hotel Gibson, Cincinnati, Ohio. Cincinnati was chosen because of its location in relation to the various foundry centers. Six committees have been appointed and it is expected that the final program will take form rapidly. It is anticipated that the first day will be devoted to outstanding industry questions. A paper will be read on each question, followed by floor discussion. Also on the first day there will be a noon luncheon and an evening banquet, with speakers and entertainment. The second day will probably be devoted to a business meeting and meetings of groups having special interests and problems.

Walter E. Barnes has been appointed assistant to F. H. Gordon, vice president in charge of sales at **Lukens Steel Co.**, Coatesville, Pa. Mr. Barnes joined the Lukens organization in 1910. He spent six years in the mills as scale weigher, marker, layerout and recorder. In 1916 he was transferred to the order department, and in 1927, to the sales department. Subsequently, he was appointed manager of claims and then assistant to general manager of sales, in which capacity he served until his recent appointment as assistant to vice president.

Announcement is made by the **Harnischfeger Corp.** of the appointment of **Harry Ewert** as assistant sales manager of the Welder Division. For the past ten years, Mr. Ewert has been identified with the production and sales of P & H Hansen welders, during which time he has been closely associated with the inventor, K. L. Hansen.

Directors of the **Blaw-Knox Co.** have created the office of chairman of the board. **Albert C. Lehman,** president, was elected to the new post in appreciation of his 30 yr. of service to the company since its inception, a resolution of the board stated. **Irvin F. Lehman,** vice president, who has also been associated with the company since its early days, was elected president, and **Frank Cordes** was made senior vice president.

M. A. Beckmann, who has been with the company since its inception and has risen to his present position of works manager, was elected a director of **Aluminum Industries, Inc.**, manufacturer of Permite products, at the annual meeting of stockholders, held in Cincinnati. Beckmann succeeds to the vacancy caused by the death of H. J. Beck, former vice president and assistant treasurer.

K. B. **McEachron,** research engineer of the **General Electric Co.** at Pittsfield, Mass., whose studies in artificial lightning up to 10,000,000 volts have brought him world-wide recognition, will receive the Edward Longstreth medal of the Franklin Institute, Philadelphia, May 15. The award is based on his contribution of "Thyrite," a substance used in more than 35 different electric applications, principally for lightning arresters. The Longstreth medal award was established in 1890 by Edward Longstreth of the Baldwin Locomotive Works, for the "encouragement of invention, and in recognition of meritorious work in science and the industrial arts."

According to an announcement of **George L. Gordon,** general manager of sales of the **Lukens Steel Co.,** the New York offices of the Company has moved to new quarters in the Chrysler Building, 405 Lexington Ave.

Those needing information about some pickling equipment and problems will be interested in an attractive pamphlet, fully illustrated (26 pages), entitled **"Equipment Designs for the Pickle House,"** just published by the **International Nickel Co., Inc.,** 67 Wall St., New York. The use of monel metal in pickling operations is stressed. Line drawings of designs for certain equipment are included.

Clifford E. Broome, formerly engineer with Wm. Ganschow Co., Chicago, and more recently with Gears & Forgings, Inc., Cleveland, Ohio, has joined the organization of the **Ajax Flexible Coupling Co.,** Westfield, N. Y., as engineer in charge of the Lectrigear division.

Four Chapter Group Meeting in New York

A group chapter meeting of decided interest will be held Friday, May 24, by the New York, New Jersey, Lehigh Valley and Philadelphia chapters of the American Society for Metals. It will be held at the Hotel Pennsylvania in New York with the New York chapter as host.

Four round table discussions will be held during the morning. The subjects and the leaders are as follows: "Stainless Steels," L. S. Bergen, Crucible Steel Co. of America, New York; "Heat Treatment in Protective Atmospheres," Sam Tour, Lucius Pitkin, Inc., New York; "Tool Room Practices," Frank R. Palmer, Carpenter Steel Co., Reading, Pa.; "Metallography," J. R. Vilella, United States Steel Corp. Research Laboratory, Kearny, N. J. These discussions will be simultaneous from 10 a. m. to 12:30 p. m. and each visitor will select the one he is most interested in.

For the afternoon session a "Three Star" program has been scheduled on the general subject "The Role of Metals in the Transportation Industry" with H. J. French, International Nickel Co., Inc., chairman. E. J. W. Ragsdale, chief of the engineering railway division of Edw. G. Budd Mfg. Co., Philadelphia, will discuss the railroad industry; J. B. Johnson, chief materials division, U. S. War Department, Air Corps, Wright Field, Dayton, Ohio, the aeronautical industry, and J. M. Watson, Hupp Motor Car Corp., Detroit, the automobile industry.

For the evening an entertainment and smoker will follow an informal dinner.

Myron H. Blanchard recently joined the **Quigley Co.,** 56 West 45th Street, New York, to take charge of the publicity and advertising activities. A. L. Diederich will assist the manager of the fire brick and insulating brick department. Mr. Blanchard will handle all advertising and publicity of "Hytempite," "Insulbrix," "Q-Chrome," "Mono-Line," "Hearth-Crete," Quigley acid-proof cements and other products in the industrial field. Previous to joining the Quigley company, Mr. Blanchard spent several years in the steel industry doing metallurgical and sales work, and was with the McGraw-Hill Co., for eight years handling copy, sales promotion, and sales work.

George H. Ralls has resigned as director of sales of the parts division of the Chrysler Corp. to become president of **Pressure Castings, Inc.,** of Cleveland. In joining Pressure Castings, Mr. Ralls has been greatly impressed with the growing demand for die castings of greater density and the progress that the company has made in this field since its organization. Pressure Castings, Inc., was organized by a group of Cleveland men who had perfected a new method of die casting which employs exceedingly high pressure and which is said to produce die castings of exceptional density. The demand for this type of die castings is requiring expansion in the original plant capacity.

The Ironton Fire Brick Co., Ironton, Ohio, manufacturers of high grade Kentucky refractories, announces the appointment of Neville & Cleary, Inc., mechanical and steam power equipment engineers, Title Bldg., Atlanta, Ga., as its exclusive sales representative for the Southern States of Tennessee, North Carolina, South Carolina, Alabama, Georgia and Florida.

A recent addition to the fast-growing list of warehouse distributors of Enduro stainless steel is the **Gilmore Steel & Supply Co.,** 825 Folsom St., San Francisco, Cal., according to an announcement by N. J. Clarke, vice president in charge of sales, **Republic Steel Corp.,** Youngstown, Ohio. With the appointment of the Gilmore Steel & Supply Co., there are now available 45 warehouse stocks of Enduro stainless steel in principal cities from coast to coast.

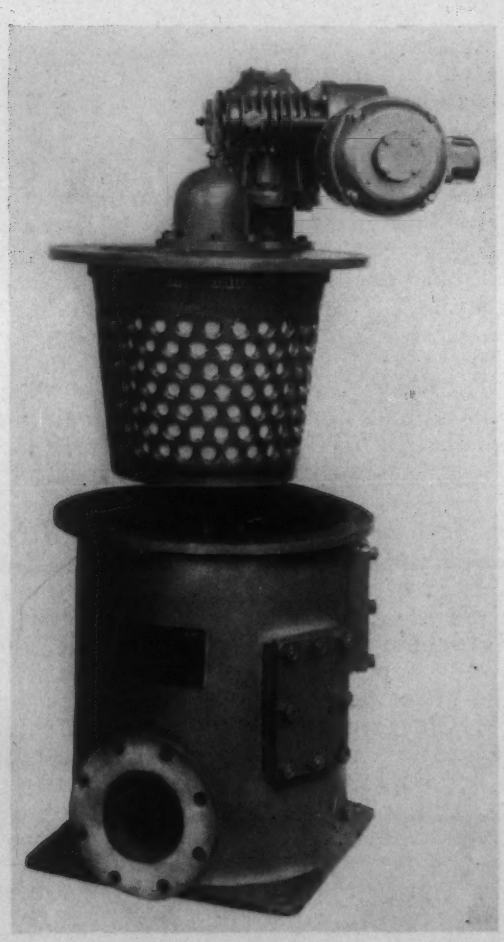
The **Lakeside Steel Improvement Co.** of Cleveland, Ohio, has recently completed the installation of a Chapmanizing unit for the hardening of low carbon steel. The Chapman Valve Mfg. Co., Indian Orchard, Mass., has granted to the Lakeside company an exclusive license for commercial Chapmanizing for northern Ohio.

New Equipment and Materials

The Brassert Automatic Strainer

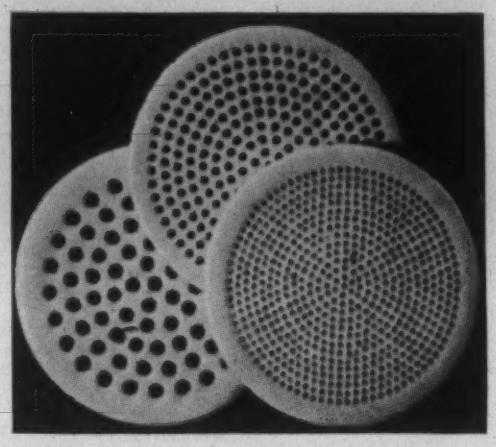
The Brassert automatic self-cleaning strainer, shown in the accompanying illustration and offered by H. A. Brassert & Co., 310 S. Michigan Ave., Chicago, consists of a conical cylinder revolving in a cast iron housing. The revolving cylinder, which contains the filtering or straining media, is supported at the top of the casing through a shaft, and is driven by a small motor and speed reducer.

Water or other liquid enters the machine through an inlet at the bottom, the water then rises between the casing and the outside of the drum and passes through the screening media held in the slowly revolving cylinder. The clean water from the interior of the drum is then discharged through the outlet at the bottom of the casing. The straining media is automatically and continuously cleaned and kept free from accumulated dirt and suspended solids by the use of approximately 5 per cent of the cleaned water.



This cleaned water used for cleaning the screens, is caused to reverse its direction of flow and jet from within the cylinder through the screening media. This water with the suspended solids is then discharged.

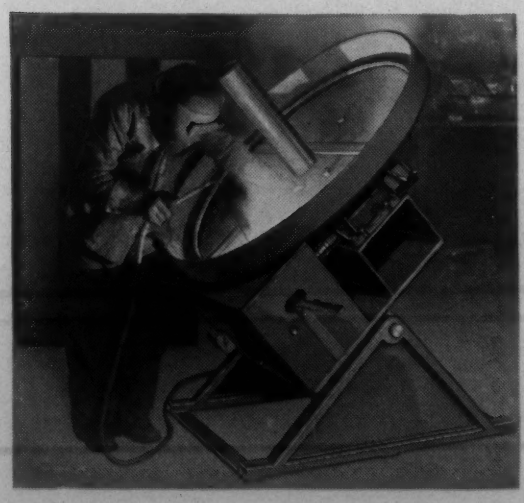
A new straining media has been developed for the Brassert automatic strainer. This consists essentially of porcelain plates glazed on one side, as illustrated, which have various sized holes in them. The plates are ¼ in. thick and contain 1/16, 1/32, and 1/64 in. holes having about the same free area as ordinary screens. The plates with 1/16 in. holes have a free area of 25 per cent, the 1/32 in. holes 22½ per cent, while the 1/64 in. holes have a free area of 13½ per cent. These porcelain plates are especially adaptable to straining water and other liquids which contain suspended matter of a fibrous nature. One advantage of the porcelain plates is that they are noncorrosive. These have been installed in a number of plants and are successfully operating on water containing quantities of fibrous material where experience has shown that ordinary screens will plug almost immediately under similar conditions. Ordinary monel metal or stainless steel screen cloth has been successfully used in these machines on certain types of water.



The strainer is particularly well suited to a service where the percentage of foreign matter in the water is high and the volume of liquid to be handled very large, as in the steel and other industries. Under these conditions, the reverse automatic cleaning feature of the strainer is effective where the stationary duplex basket type strainer is impractical. Here the Brassert automatic strainer will operate and deliver a steady flow of finely cleaned water under pressure, through fine mesh straining media, thus protecting pipe lines, valves, spray nozzles, pumps, meters, cooling pipes, condensers, etc., from the abrasion or clogging caused by grit or other solids which the ordinary strainer cannot remove.

New Fixture Cuts Welding Time 60 per cent.

A new type welding fixture with an inclined turntable arrangement for easier handling of circular pieces has been recently perfected by the Harnischfeger Corp., Milwaukee. To enable the operator to weld continuously in a downward position, the turntable is equipped with an electrical rotating mechanism with gear shift and variable speed motor control. Speed can be accurately regulated from 3 to 18 in. per min. in either direction at the circumference of the 42 in. table. Thus, for example, in welding a circular piece, the operator may hold the rod in a steady position as the work passes beneath it at the desired speed. The turntable can be tilted from one side of the base to the other or held in a horizontal position. Recently, fabricating time on a huge gear was reduced from 32 to 13 hr. when 65 rods, (⅜ in.) were deposited in 2 hr. Although primarily designed for handling circular shapes, it also handles other unwieldy pieces. Known as the "RT," this new fixture is offered in various sizes to handle loads up to 4 tons.

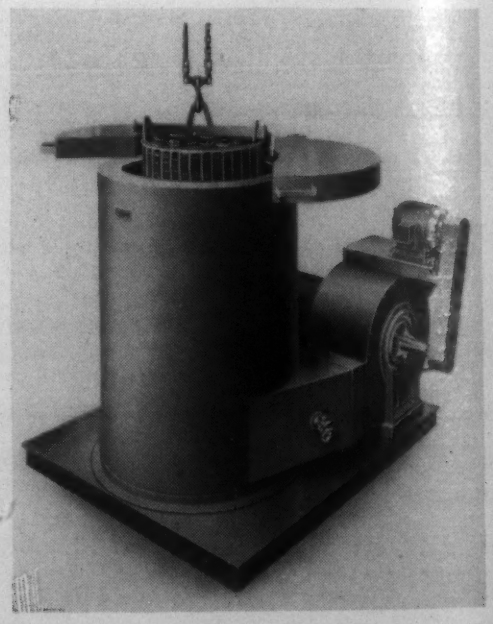


Large Plates, 25 In. Thick

A new "Size Card" has been issued by the Lukens Steel Co., Coatesville, Pa., showing the sizes of rectangular and circular plates which the company produces. In announcing this card, the company emphasizes the fact that thick steel plates, up to 25 in. in thickness, can be furnished for bridge and building bases, die work, fly wheels for welded steel structures for machinery and equipment and for other purposes. The statement is also made that extremely wide plates, up to 186 in., are coming into use more and more in the fabrication of boilers, tanks and pressure vessels.

New Cylindrical Air-Draw Furnace

A newly developed line of cylindrical air-draw furnaces is announced by the Industrial Gas Engineering Co., Chicago. As shown by the illustration, the new furnace is portable, the complete equipment being mounted on a steel base, and is provided with a split cover having a center opening, facilitating the handling of the treated material by hoist and permitting the treating of long, thin parts in suspension so as to eliminate warping and bending.



The new method of heating the furnace is similar to the universal recirculating method introduced and pioneered by the Industrial Gas Engineering Co. The principle of this method consists in circulating a large volume of heated air rapidly throughout the furnace, thus attaining a quick heating up and heat transfer to the furnace load as well as a uniform furnace temperature. The heating system is simple in construction and operation and so flexible that any temperature from 250 to 1250 deg. F. can readily be obtained and automatically maintained.

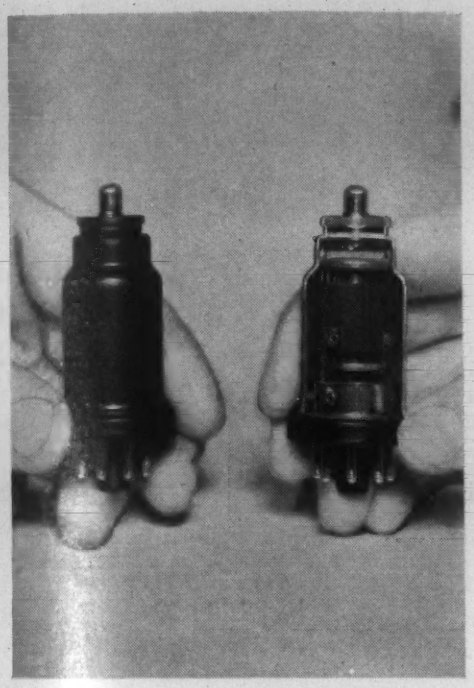
The furnace is suitable for all processes requiring temperatures from 250 to 1250 deg. F. such as in the drawing of carbon, high-speed and alloy steel

and in the annealing and tempering of brass, copper, aluminum and various aluminum alloys.

Three standard sizes of this equipment are available: type CF-1: 24 in. in diameter and 36 in. deep; type CF-2: 30 in. in diameter and 48 in. deep and type CF-3: 36 in. in diameter and 60 in. deep. Other sizes and types are made to order. Due to the high efficiency of the whole equipment, the operating cost of these furnaces is low.

New Radio Tubes of Metal

A new line of metal radio tubes, which tests indicate to be of greater continued efficiency of operation than the glass type now in use, has been



announced by the General Electric Co. Developed in the research laboratories of the company at Schenectady, these new metal tubes are not only much smaller and more sturdy, but are claimed to offer many improved electrical characteristics over the conventional tubes of today. They provide their own shielding and this metal shell is a better heat conductor and radiator than glass. They are particularly advantageous in the field of short wave reception. The short leads of the tubes permit greater amplification at the higher frequencies and the more effective shielding insures greater stability. These new tubes are not interchangeable with glass tubes in the present type radio receivers and will make their first appearance in the new fall line of General Electric sets.

The metal tubes are cylindrical in form, some in reduced diameter at the top. Others, such as radio frequency amplifier, have a terminal at the top extremity. Each lead-in wire passes through a tiny bead of special glass that is fused securely within an alloy eyelet, which in turn is welded to the metal container, thus assuring a long life vacuum. This alloy, having substantially the same coefficient of expansion as glass, is known as "Fernico" and is a combination of iron, nickel and cobalt. It was developed expressly as a perfect seal on the new tubes.

The familiar metal shield which is necessary with the glass tube in radio-frequency portions of a circuit is no longer required with the new tube. The metal envelope itself serves as a shield. And, since closer proximity of shield to elements can be realized, the shielding is more effective. A further favorable feature of the metal shell, General Electric engineers believe, is that it contributes to residual gas cleanup, thus promoting continued efficiency of operation.

The metal construction has been applied both to existing types of glass tubes having indirectly heated cathodes, and to other newly developed tubes. Included in these is a duo-diode, which is only about ⅝ in. high above the base, and a hexode, which is an improved pentagrid converter.

The glass-to-metal seal, as developed in the General Electric Research laboratory, utilizes a special alloy as before mentioned, the expansion characteristics of which coincide almost exactly with the glass used for sealing. For this reason no stresses are set up in either the glass or the alloy when cooled from the fusion temperature. This lack of initial internal stresses in the completed seal makes it permanently tight and unusually strong.

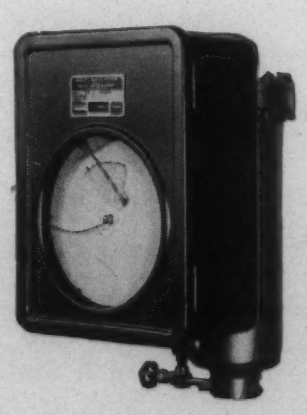
Thyratron-tube control for the timing of the welds, one of the most important improvements in welding practice in recent years, itself a G-E development, is used in sealing metal headers to the cylindrical envelopes or shells, and for attaching metal parts to the headers. Thyratron-tube controlled welding not only makes possible new types of welds with material previously unsuited to welding, but also insures reproducibility of any given weld. For the small envelopes or shells of radio tubes, spot welding is used; only 1/20 sec. is needed to make a vacuum-tight weld around the circumference of shells 1 in. in diameter. Seam welding is used for larger industrial-type tubes.

The new metal technique is applicable not only to radio tubes but to various types of industrial vacuum tubes as well. Large rectifiers, shield-grid Thyratron tubes, and numerous other types have been made with metal construction.

Fuel Flow-Air Flow Meter for Furnaces and Kilns

A new fuel flow—air flow meter, recently developed by Bailey Meter Co., Cleveland, Ohio, guides operators of furnaces and kilns so that they are able to obtain maximum combustion efficiency from the fuel burned.

The primary purpose of the Bailey fuel flow—air flow meter is to provide furnace operators with an easily understandable guide which enables them to maintain a definite relation between the amounts of air and fuel supplied to the furnace, thereby securing the highest possible combustion economy. This is accomplished by an ingenious method. The meter contains two recording pens, one records the rate of oil flow or gas flow and is actuated by a simple mechanical mechanism which receives its motive power from the differential pressure produced by an orifice in the fuel line. In a similar manner the second pen records the flow of air supplied for combustion.



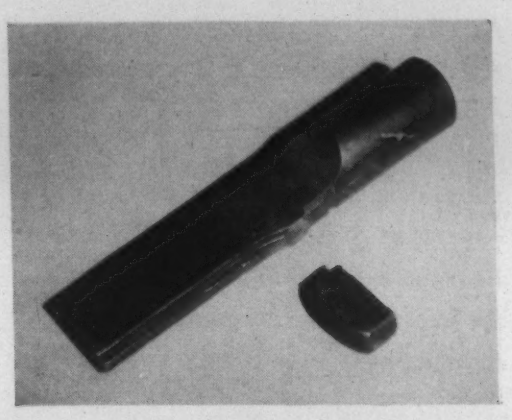
At the time the meter is installed, a complete combustion test is made to determine the ratio btween fluel flow and air flow, which results in best combustion conditions. After this ratio is determined, the air flow mechanism is adjusted so that the two records coincide, one upon the other, when best combustion conditions are obtained. The furnace operator, therefore, has merely to keep the two pens together for proper manipulation of the air supply to secure the desired economy of fuel consumption.

Should the air flow pen be above the fuel flow pen, it is an indication that too much air is being supplied with a consequent increase of stack losses. Conversely, should the air flow pen be below the fuel flow pen, it is an indication that too little air is being supplied with consequent loss due to unburned fuel.

In addition to serving as a combustion guide, the Bailey ratio meter is valuable as a fluid meter on the fuel line.

Hard-Faced Punch Has Long Life

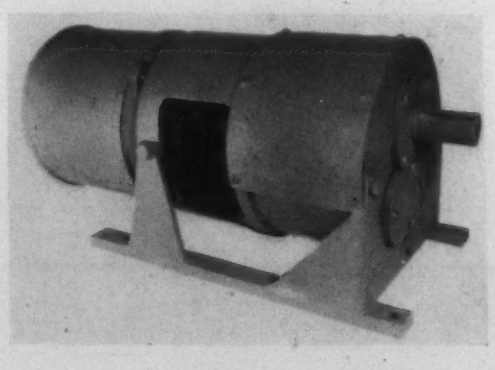
The hard-faced punch, as illustrated, used for hot punching jaw slots in wrenches, has an average life per grind of 7800 pieces as compared with 600 pieces for a plain steel punch. The slug in the illustration is of 0.80 per cent carbon steel and is punched out



of ¾-in. stock. Other sizes range from ¼ in. to 1 in. in thickness. The punch is faced with cobalt-chromium-tungsten alloy, a material unique in its hardness and abrasion-resistance at elevated temperatures. This hard-facing application has been standard since 1929, with the Haynes Stellite Co., 205 E. 42nd St., New York.

A Helical Gear Reduction Unit

The Ajax Flexible Coupling Co., Westfield, N. Y., announces a helical gear reduction unit called the Lectrigear to be made in sizes ranging from ⅛th to 2 h.p. Standard footless motors are used without any changes in shaft or bearings. Lectrigears can be fur-



nished either with or without motors. Two characteristics differentiate the Lectrigear from previous designs: (1.) It is unnecessary to use a specific make of motor, there being several standard makes that can be used without change, (2.) Lectrigears can be furnished without motors which permits the user to provide his own motors and do his own assembly work, a simple operation taking but a few minutes.

A Boiler Solder for Repairing Leaks

A new boiler super-solder—for servicing leaks in steam and hot water heating plants—is announced by the Dole Valve Co., 1901 to 1933 Carrol St., Chicago. It has been given the name "Dole Sodrin." The new product is made from a base of pure aluminum and contains synthetic solder which melts in hot water but which hardens instantly when cooled at the leak by air. Circulation of the water in the boiler or pipe carries Dole Sodrin to the leak where it is said to build up a metallic repair.

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